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PACKINGHOUSE WASTE TREATMENT

Ralph Stone and Company, Incorporated

Prepared for:

Environmental Protection Agency

April 1970

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PACKINGHOUSE WASTE TREATMENT

by

Stockton Public Works Department
Stockton, California

Project #11060 DRT

Project Officer

Harold G. Keeler
Industrial Pollution Control Branch
U.S. Environmental Protection Agency
Washington, D.C. 20460

Prepared for

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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PACKINGHOUSE WASTE TREATMENT,

~~Public Works Department~~
~~Stockton, California~~

EPA Project 11060 DRT

9.

Ralph Stone and Company under contract to City of Stockton, California, Public Works Dept.

Environmental Protection Agency, Report, (April 1970). 238 p, 34 fig, 45 tab.

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Laboratory tests were designed to study the oxygen uptake, contact time, potential foaming and scum problems, flow characteristics, odors, BOD removal efficiency, clarification, and return of activated sludge of high suspended solids mixed liquor reactors using packinghouse wastes.

Sampling and analysis of the sewer flow and gases generated, along with work on in-sewer treatment and corrosion protection were evaluated as part of the pretreatment process.

Main water quality control plant description and operations were given along with the results of an extensive sewage sampling program.

An economic analysis was made of the different pretreatment processes and of central treatment. Pretreatment of the waste was shown to be economically desirable. (Scaief - EPA)

*Aeration, *Activated Sludge, *Food Processing Industry, *Waste Water Treatment, Biological Treatment, Corrosion Control, Sampling, Sewage, Sewers

*Meat Packing Wastewater, *U-Tube Aeration, *In-Sewer Treatment, Sewer Gases, Pretreatment

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ABSTRACT

This report covers the feasibility studies to develop and demonstrate pretreatment of packinghouse wastes for discharge to a municipal treatment system. The pretreatment consists of a high mixed-liquor activated sludge (Kehr) process in conjunction with in-sewer treatment.

The study components consist of the Swift and Company meat packing wastewaters, the Southern Industrial Sanitary Trunk Sewer, and the City of Stockton, California Main Water Quality Control Plant. A description of the Swift plant includes plant operations and water use. The wastewater generated is characterized and the field sampling program and analytical procedures are described. Laboratory investigations were undertaken to study the oxygen uptake, contact time, potential foaming and scum problems, flow characteristics, odors, BOD removal efficiency, clarification, and return of activated sludge in the Kehr process using the Swift wastewaters. Sampling and analysis of the Southern Industrial Trunk flow, and gases generated, were undertaken and in-sewer treatment and corrosion protection were evaluated as part of the pretreatment process. A bench model of a collapsible dam was constructed for evaluation of its capability in corrosion protection. Finally, the report describes the Main Water Quality Control Plant and includes the results of an extensive sewage sampling program. These results show the effect of the Swift wastewaters on the Main Water Quality Control Plant.

The report contains an economic evaluation of the different pretreatment processes and of central treatment. Pretreatment of the waste is shown to be economically desirable.

This report was submitted in fulfillment of Project Number 11060 DRT by Ralph Stone and Company under sponsorship of the Environmental Protection Agency. In order to speed the dissemination of the material, rather than retype the original, part was deleted that was extraneous to the Environmental Protection Technology Series. This deleted material, a description of the San Joaquin Valley in the Stockton area and related figures, and subsequent format changes explain the discontinuity in the numbering of the sections.

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CONCLUSIONS

The use of pretreatment has been evaluated in the laboratory to reduce the waste load from a meat packing plant on a municipal sewage treatment plant. The pretreatment consisted of a high mixed-liquor activated sludge (Kehr) process in conjunction with in-sewer treatment.

A series of six laboratory reactors were run; both the aeration unit and clarification unit consisted of one-liter bottles. Results were generally inconclusive because of sludge foaming or plugging problems. The two reactors that showed more promising operating characteristics reduced the corresponding influent BOD of 520 and 550 mg/l to 40 and 60 mg/l respectively. This was a BOD reduction of approximately 90 percent in a detention time of between six and seven hours.

A second set of laboratory reactors was run using aeration and clarification units of 2.4 liters. Six hours of aeration produced a BOD reduction averaging 90 percent, BOD concentration in the waste went from approximately 600 mg/l to 60 mg/l. The clarified effluent after six hours of settling was a pale to clear liquid. Odors were classified as musty. The effluent from the aeration unit contained suspended solids which settled within 30 minutes. Foaming and clogging of the tubing was minimal. After clarification the suspended solids level was approximately 150 mg/l, down from about 500 mg/l in the raw waste for a 70 percent reduction.

In-sewer treatment methods designed to reduce the formation of sulfides included the addition of chemicals and aeration. Available oxidizing chemicals considered most promising for application to the sewer were hydrogen peroxide, chlorine, and sodium nitrate. The costs of treatment with chlorine and peroxide were about equal, with an annual cost of $5000/mgd. Treatment with sodium nitrate was less costly ($3000/mgd), but was ineffective due to the long detention time required for oxidation of the sulfides. The prospects for sulfide control by chlorine were good and hydrogen peroxide proved promising enough to warrant further tests. Later field tests showed that application of hydrogen peroxide was not feasible due to its rapid decomposition rate constant of 0.11/min. giving it a half-life of 6.2 minutes.

Two methods of in-sewer aeration were considered. The first was installation of air piping in the invert of the sewer upstream from a weir. The primary drawback was the low rate of oxygen transfer, in the neighborhood of 1 percent, consequently the number of blowers and length of air piping needed would not be economically feasible. A second system evaluated in the laboratory was the use of U-tubes at several points in the Southern Industrial Trunk. This type of system consisted of two elements: a device for entraining air or oxygen into the flowing wastewaters; and a vertical U-shaped flow path to provide residence time during which oxygen absorption could take place. The U-tube method was well suited to raise the dissolved oxygen concentration of water or sewage from a low value to a value approaching saturation with a relatively short residence time. The oxygen transfer through a 40 ft deep U-tube was estimated to be 60 to 70 percent of saturation.

Based on an oxygen demand for the pretreated and untreated wastewater of 3 and 7 mg/1 per hour respectively, to protect the Trunk Sewer five U-tube stations would be needed if pretreatment was provided, and six stations without pretreatment. Cost of construction of five U-tube stations was estimated to be $127,800. For six stations construction costs were estimated to be $157,700. Annual costs were estimated at $18,900 and $26,300 respectively.

An additional benefit from in-sewer treatment was a contribution to corrosion protection due to keeping the sewage fresh, thus inhibiting the formation of sulfuric acid.

The effect of Swift wastewaters on the Main Water Quality Plant was shown to be approximately 7 percent of the city's total hydraulic flow on an average day during the dry season when nearby canneries were not operating. BOD and suspended solids contribution was 18 and 16 percent respectively during the non-canning season. During the canning season the contribution was 4 and 3 percent respectively.

RECOMMENDATIONS

1. After further testing on a larger scale to refine the design parameters, it is recommended that the following demonstration facilities be constructed:

   A. 1.5 mgd high mixed-liquor (Kehr Process) activated sludge treatment plant at the westerly corner of the Swift property.

   B. Five U-tube aeration systems in the 42 and 48 inch diameter sections of the Southern Industrial Trunk.

2. Finally, further refinement of cost projections should be made based on the data obtained in the above recommendations.

I. INTRODUCTION

A. OBJECTIVES

The basic objective of the study was to develop, demonstrate, and evaluate pretreatment for packinghouse wastes; the pretreatment consisting of a high-rate activated sludge, or Kehr process, plant in conjunction with in-sewer treatment.

A one-year feasibility study for the proposed three-year total program was initiated. The objectives of the one-year study were to determine the following:

- The efficiency of the Kehr process (high-rate activated sludge) for the treatment of high-strength BOD[1] meat packing wastes.
- The economic cost-benefits of activated sludge treatment of the Swift and Company[2] high-strength BOD wastewater at an upstream treatment plant.
- The technical and economic cost-benefits of upstream treatment on sewer corrosion in comparison to the cost-benefits of no upstream treatment and conventional downstream central treatment plant operation.
- The technical and economic practicality of in-sewer treatment of wastes in the Southern Industrial Sanitary Trunk Sewer.[3]

B. SCOPE

The above objectives determined the scope of the one-year study program, which was a cooperative effort sponsored by the Public Works Department of the City of Stockton in conjunction with the Swift meat packing plant located in the City. The study system consisted of the Swift industrial waste facilities, the Southern Industrial Trunk, and the City's Main Water Quality Control Plant.[4]

The following summary outline describes the overall scope of work:

---

[1] BOD throughout this report is defined as 5-day biochemical oxygen demand.

[2] Hereafter referred to as Swift.

[3] Hereafter referred to as Southern Industrial Trunk.

[4] Hereafter referred to as Main Water Quality Plant.

Field Studies

____ Comprehensive sampling and laboratory analysis to determine the quantity and characteristics of industrial wastes generated by Swift, and their effect on the City's Southern Industrial Trunk, treatment plant, and receiving waters.

____ A detailed study of the connecting Southern Industrial Trunk line extending from the packing plant to the treatment plant, including determination of sources of influent, gas sampling, wastewater sampling, and structural evaluation.

____ Full-scale testing using hydrogen peroxide to protect the sewer.

In-house Studies

____ Evaluation of alternative methods of protecting the sewer, including chemical additives, aeration, flushing, and flow control.

____ Evaluation of prior work by others on high-rate activated sludge treatment (Kehr Process) for application to upstream treatment of Swift industrial wastewater.

____ Analysis of the three (3) separate one-month-long field sampling program results and determination of the effect on the City's treatment works and receiving waters of the industrial waste from Swift.

____ Pilot plant studies on conventional and high-rate activated sludge treatment.

____ Laboratory tests to determine oxygen demand of untreated and partially-treated Swift wastewater.

____ Laboratory tests of U-Tube concepts for in-sewer aeration.

____ Laboratory and field tests using hydrogen peroxide for sewer protection and pre-conditioning Swift industrial waste for subsequent downstream treatment.

____ Conceptual design of alternative upstream industrial waste treatment plants.

____ Cost estimating for construction and operation of industrial waste treatment works and in-line sewer devices.

____ Economic analysis of the various combinations of upstream and downstream treatment and sewer protection methods.

II. SWIFT AND COMPANY PLANT

A. DESCRIPTION

1. Location

The Swift meat packing plant is located in the southeastern corner of the City of Stockton (see Figure II-1), on Mariposa Road, one-half mile southeast of State Highway 99.

2. Operations and Plant Layout

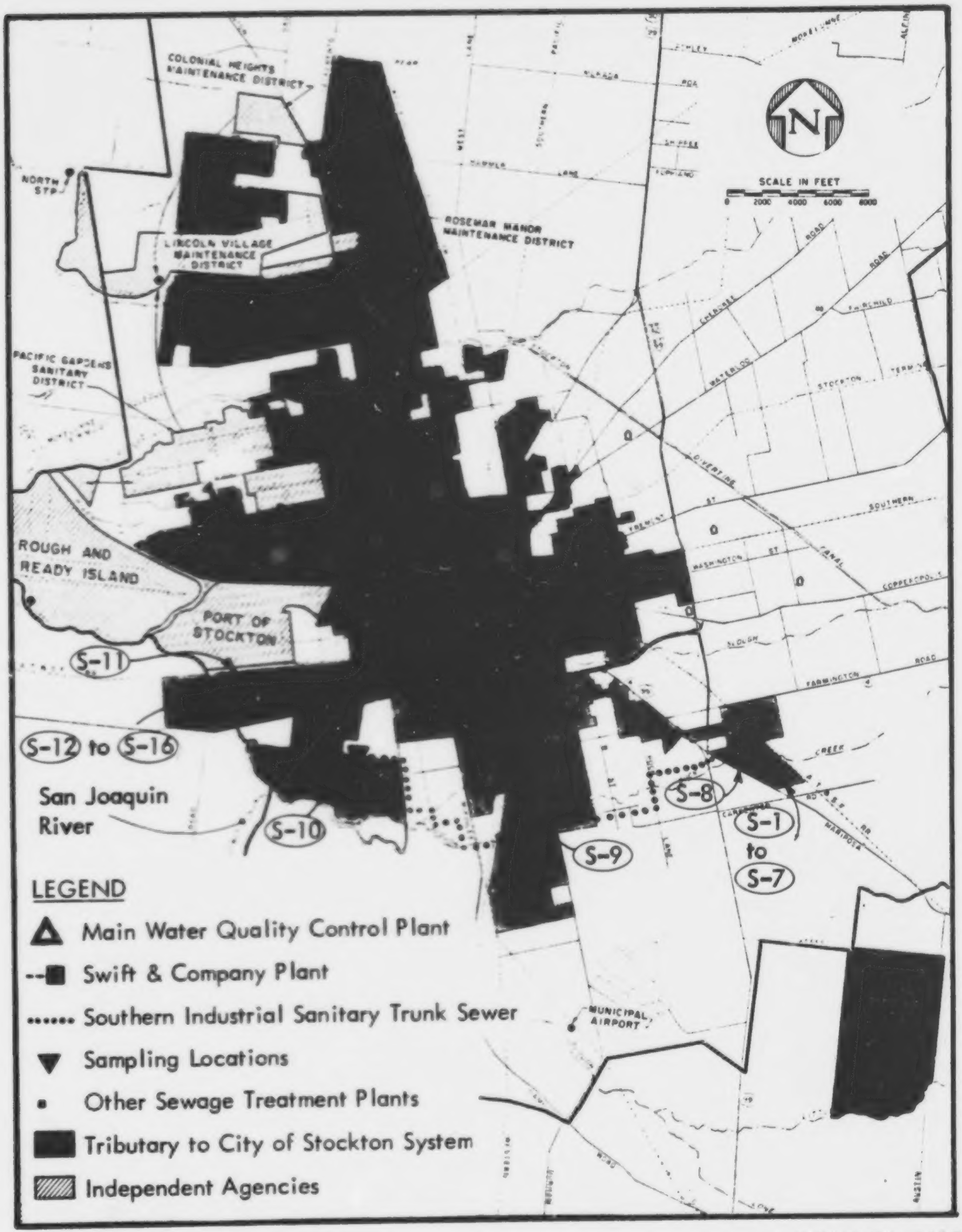
The meat packing plant started operation in January 1969. For the first six months the plant production gradually increased as plant operations were modified, refined, and became routine.

During the April 1969-1970 one-year study period, only beef cattle were processed at the plant. Normally, the plant operated five days per week. Production has been on a daylight one-shift basis followed by plant clean-up at night.

The primary plant operations performed were cattle killing, processing, hide curing, inedible rendering, edible rendering, and cold storage. Figure II-2 is a schematic layout of the Swift plant.

The meat packing process is illustrated schematically on Figure II-3. Cattle for one day's kill were typically delivered to the stockyards in the late afternoon and early evening of the preceding day and kept in pens. If the weather was hot the cattle were kept comfortable by overhead water mist sprays. The meat packing normally began with the 6:00 A.M. shift and continued until the shift ended at varying times ranging from about 2:00 to 4:00 P.M. After the cattle were immobilized with a mechanical air stunner, a schueber chain was attached to one of their hind legs, and they were hoisted to an overhead conveyor. This conveyor carried them over a pit for sticking and bleeding. From here they were moved past various stations where heads, legs, and hides were removed. After the head had been removed, each horn was clipped off with automatic cutters and the head was suspended on conveyor hooks. Then the tongue was removed and suspended on a hook next to the head. These parts were then transported by conveyor to be washed by warm water and further processed. Hides were removed mechanically and taken directly to the curing area by a chain conveyor.

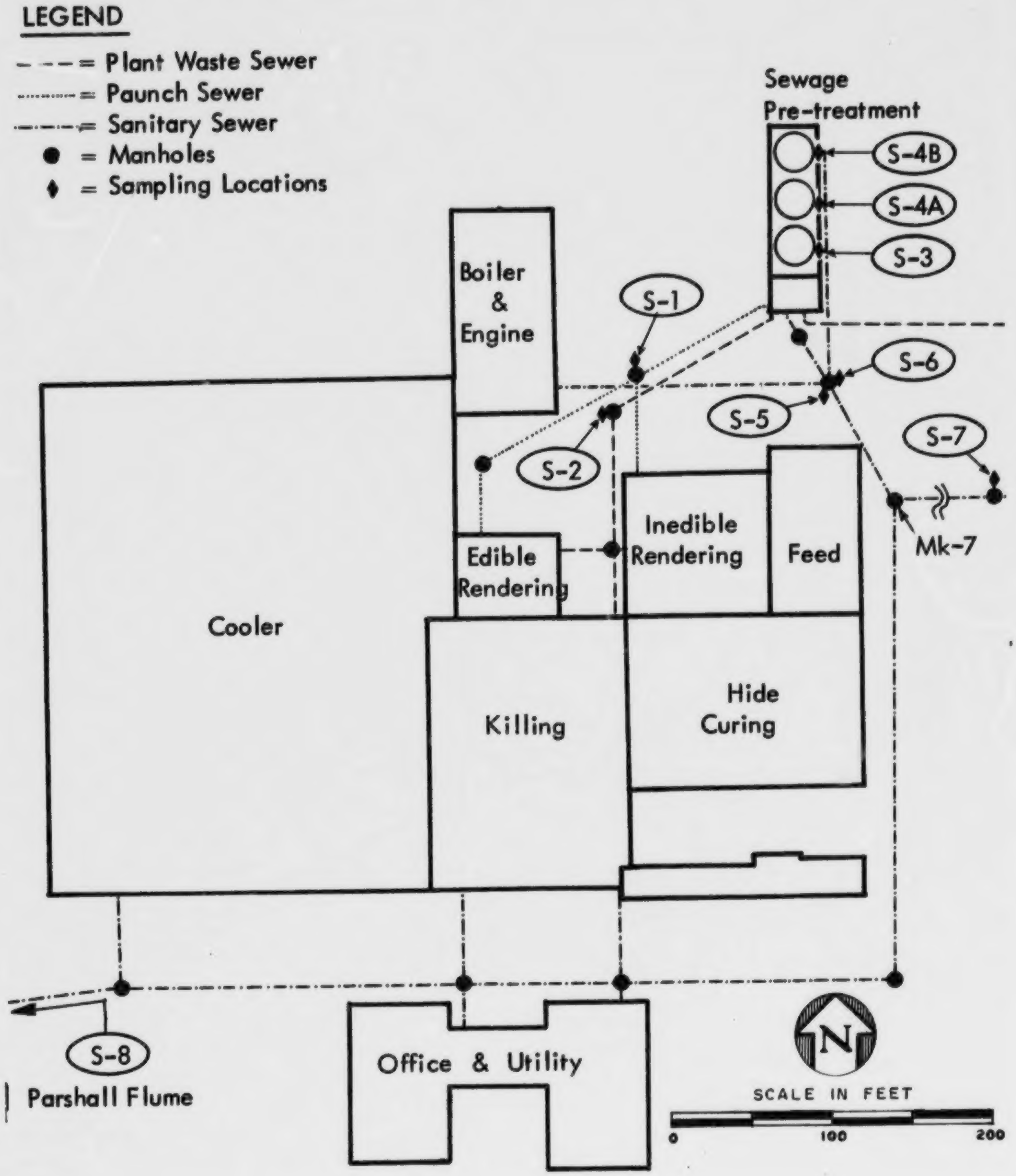
The carcass was next passed over a continuously washed conveyor table where viscera were separated by operators standing on the moving platform. The carcasses were moved mechanically from the table and the viscera were segregated for edible or inedible rendering, and further processing. The large intestines were moved through rollers and washed prior to being processed for use as sutures. The paunch was cut and


COLONIAL HEIGHTS MAINTENANCE DISTRICT
NORTH STP
LINCOLN VILLAGE MAINTENANCE DISTRICT
ROSEMAR MANOR MAINTENANCE DISTRICT
PACIFIC GARDENS SANITARY DISTRICT
ROUGH AND READY ISLAND
PORT OF STOCKTON
N
SCALE IN FEET
0 2000 4000 6000 8000
S-11
S-12 to S-16
San Joaquin River
S-10
S-9
S-8
S-1 to S-7
MUNICIPAL AIRPORT
WATERLOO
DIVERTING
SOUTHERN
WASHINGTON ST
COPPEROPOLIS
FARMINGTON ROAD
MARIPOSA
CREEK
LEGEND
△ Main Water Quality Control Plant
--■ Swift & Company Plant
...... Southern Industrial Sanitary Trunk Sewer
▼ Sampling Locations
• Other Sewage Treatment Plants
■ Tributary to City of Stockton System
▨ Independent Agencies

City of Stockton
Swift & Co. – FWPCA Project

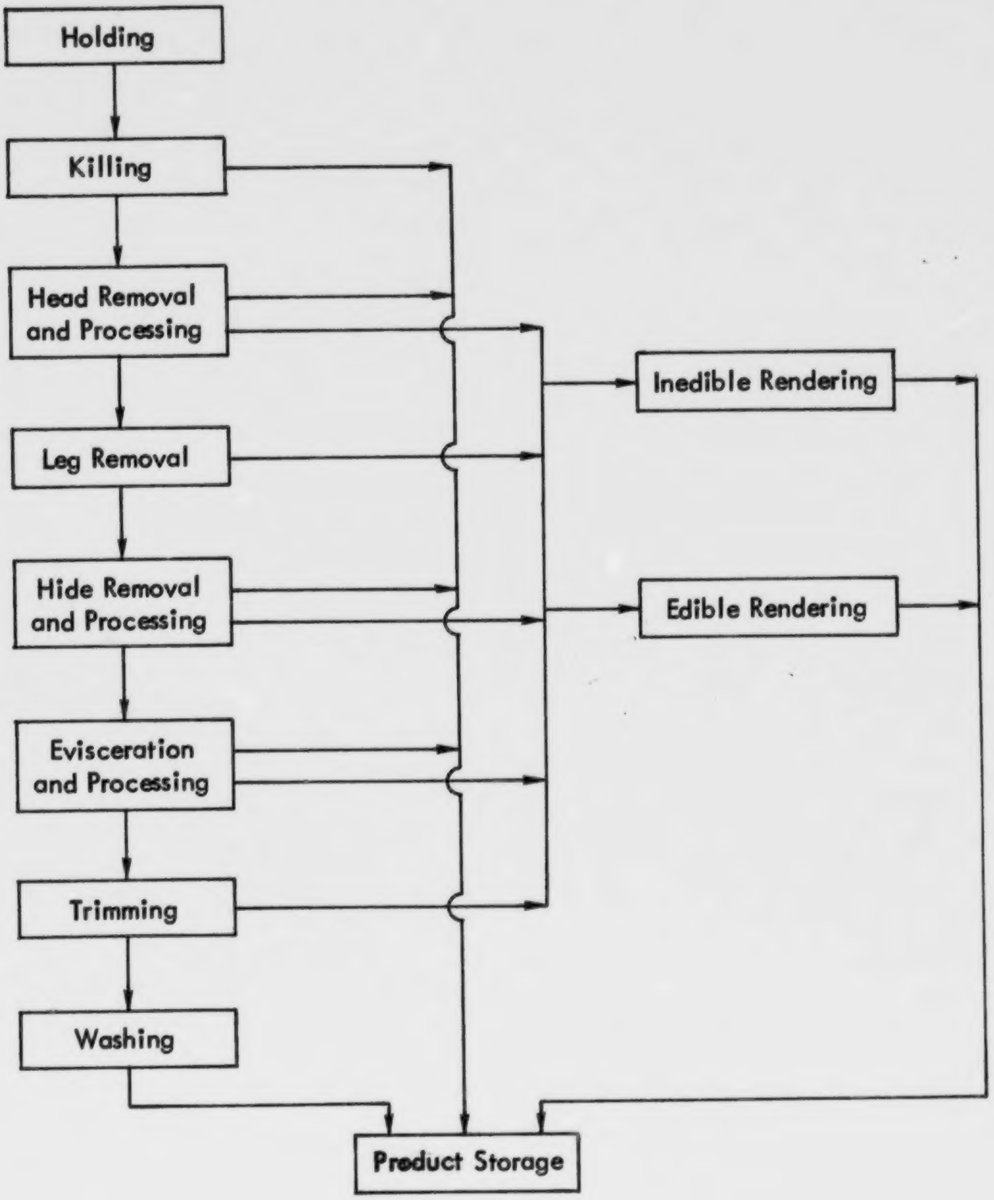
LOCATION MAP

FIGURE II-1


LEGEND
- - - = Plant Waste Sewer
······· = Paunch Sewer
-·-·- = Sanitary Sewer
● = Manholes
♦ = Sampling Locations
Sewage Pre-treatment
S-4B
S-4A
S-3
S-1
S-6
S-5
S-2
S-7
Mk-7
Boiler & Engine
Cooler
Edible Rendering
Inedible Rendering
Feed
Killing
Hide Curing
Office & Utility
S-8
Parshall Flume
N
SCALE IN FEET
0
100
200

City of Stockton
Swift & Co. - FWPCA Project

PLANT SCHEMATIC
SWIFT AND COMPANY
FIGURE II-2


Holding
Killing
Head Removal and Processing
Leg Removal
Hide Removal and Processing
Evisceration and Processing
Trimming
Washing
Inedible Rendering
Edible Rendering
Product Storage

City of Stockton
Swift & Co. - FWPCA Project

MEAT PACKING
PROCESS SCHEMATIC

FIGURE II-3

its contents emptied. The paunch lining was then washed several times. Other organs were also cleaned and washed, and wastes were conveyed for edible or inedible rendering. Edible meat components were inspected by United States Department of Agriculture veterinarians, and unacceptable animal components were processed by inedible rendering.

The carcass was cut down the back into halves, trimmed, and inspected. The sections of beef were weighed, washed automatically in an enclosed chamber, and washed again by hand-held hoses. Cotton shrouds were wrapped around each carcass and they were conveyed to chilled storage. In the early morning (12:00-8:00 A.M., during the clean-up shift) on the next day, these shrouds were removed, washed, and then reused.

After the killing had ended, the down-line processing soon terminated and plant clean-up continued through most of the evening and early morning.

Plant facilities were constructed of corrosion-resistant materials in order to promote cleanliness and reduce maintenance.

3. Water Use

The Swift plant in Stockton purchased potable and processed water from the California Water Service. Table II-1 contains a typical analysis of their well waters. The water was of excellent quality, with a total dissolved solids concentration of 213 mg/l and a calcium carbonate concentration (hardness) of 30 mg/l. The two unusual characteristics of the water were the relatively high silica and sodium concentrations--63 and 48 mg/l, respectively.

Swift has obtained water from this well source since December 1968 in the quantities shown in Table II-2. Since May 1969, water consumption has ranged from 1.44 to 1.70 mgd. This usage can be considered as typical for normal one-shift plant operation. Prior to May 1969, water use was considerably less because the new plant was not yet in full production. Water for irrigation of landscaping was drawn from an on-site well operated by Swift. Attractive landscaping in front of the plant and office building included a large grassed area, a decorative lake, and landscaped bushes and trees. The westerly section of the plant site was undeveloped and supported natural vegetation such as wild grass and brush.

4. Solid Waste

Solid waste at Swift was of three types: general office; receiving and shipping; paunch manure and paunch sludge. General office, receiving and shipping wastes were primarily paper products including some light lumber from packaging. The quantities of paunch manure and paunch sludge generated during the Summer and Winter Sampling Periods are shown in Table II-3. Paunch manure consisted of the undigested contents of the paunch; it weighed about 40 to 50 lb per 1000 lb of beef. It was extracted from

TABLE II-1

WATER CHARACTERISTICS[1]

Characteristic	Concentration (mg/l unless otherwise noted)
Carbonate (CO_3)	1
Bicarbonate (HCO_3)	146
Sulfate (SO_4)	2
Chloride (Cl)	13
Nitrate (NO_3)	0
Calcium (Ca)	8
Magnesium (Mg)	2
Sodium (Na)	48
Potassium (K)	3
Hardness ($CaCO_3$)	30
Alkalinity ($CaCO_3$)	120
Silica (SiO_2)	63
Manganese (Mn)	0.03
Iron (Fe)	0.06
Phosphate (PO_4)	0.44
Fluoride (F)	0.15
Carbon Dixoide (CO_2)	2
Total Dissolved Solids	213
Iodide, ppb (I)	14
Specific Conductance, micromhos/cm, at 25°C	263
Water Temperature, °F	70°
Hydrogen Ion, pH	8.1

---

[1] February 7, 1969 analysis by California Water Service, Stockton, California.

TABLE II-2

WATER USE AND WASTEWATER DISCHARGES

Month	No. of Working Days	Water Consumption[1]		Wastewater[2]		Monthly Difference (MG)
		Monthly (MG)	Average Daily (MGD)	Monthly (MG)	Average Daily (MGD)	
(1968)						
December[3]	22	9.83	0.45			
(1969)						
January	22	14.30	0.65	16.57	0.75	+ 2.27
February	20	22.05	1.10	23.44	1.17	+ 1.39
March	21	22.41	1.07	31.63	1.51	+ 9.22
April	22	26.85	1.22	22.58	1.03	- 4.27
May	21	32.71	1.56	22.61	1.08	- 10.10
June	21	30.66	1.46	19.19	0.91	- 11.47
July	22	33.11	1.50	20.23	0.92	- 12.88
August	21	34.94	1.66	23.12	1.10	- 11.82
September	21	37.26	1.77	22.63	1.08	- 14.63
October	23	35.32	1.54	25.88	1.13	- 9.44
November	19	32.86	1.73	32.20[6]	1.69	- 0.66
December	22	32.84	1.49	28.80	1.31	- 4.04
(1970)						
January	21	30.26	1.44	29.67[6]	1.41	- 0.59
February	20	30.02	1.50	29.44[6]	1.47	- 0.59

TABLE II-2 (Continued)

[1] From meter readings by California Water Service, Stockton, the 28th of each month for the period beginning the 28th of the preceding month. Volume of water used by Swift and Company, except irrigation water.

[2] From the City of Stockton monthly sewer service charge records, based on meter readings at Swift and Company's Parshall flume. Tabulated for the period from the 1st of one month to the 1st of the following month. The Parshall flume was not working properly because the controller and recorder were not properly calibrated. After November 1969 it was no longer used by the City to measure plant flow for sewer service charge computation.

[3] Average for working day.

[4] Start-up period. No meatpacking.

[5] Start-up period. Meatpacking operations started in the middle of the month.

[6] Quantity computed as 98 percent of water consumption.

TABLE II-3

PAUNCH SLUDGE AND PAUNCH MANURE SOLID WASTES[1]

Period	No. of Head	Paunch Sludge 1,000 lb	Paunch Manure 1,000 lb
		Summer Sampling	
8/25 - 8/29	4,421	194	200
9/ 2 - 9/ 5	3,592	144	162
9/ 8 - 9/12	4,515	177	203
9/15 - 9/19	4,516	209	203
9/22 - 9/26	5,481	200	247
Subtotals	22,525	924	1,015
Daily Averages	939	38	42
Per Head	--	0.040[2]	0.045
		Winter Sampling	
1/ 5 - 1/ 9	3,548	134	159
1/12 - 1/16	3,823	218	173
1/19 - 1/23	3,962	250	178
1/26 - 1/30	3,383	164	172
Subtotals	14,716	766	682
Daily Averages	736	38	34
Per Head	--	0.052[2]	0.046

---

[1] From Swift and Company records.

[2] Contains liquids as well as paunch solids.

the paunch in the killing room and was carried by a dewatering screw conveyor and other screw conveyors to the inedible rendering building; the residue wastes were dumped into a 20 cu yd enclosed bin. When full, the bin was picked up by a private hauler and transported to a sanitary landfill for disposal. The paunch meat was cleaned with water in an umbrella washer and further processed for sale as tripe. Paunch sludge was the solid waste skimmed off the existing paunch air-flotation treatment tank and the grease slurry from inedible rendering. The waste was heat-treated with steam and discharged into a 6,000 gal tank trailer (see Photograph II-1). When the tank was filled, the paunch was transported to a sanitary landfill for disposal. Forty to 60 lbs of concentrated paunch sludge slurry were discharged per head of cattle processed. The paunch sludge is reportedly difficult to process with conventional wastewater treatment methods, for example, it may upset activated sludge treatment works. Hence, paunch sludge is normally disposed into a landfill. Skimmings from the two air-flotation tanks were primarily grease. The skimmings were piped and processed for inedible or other by-products.

5. Cattle Processing

During the first six months, plant operations were modified and improved. Plant production rates gradually increased to a point where the market for beef influenced the rate of plant operation.

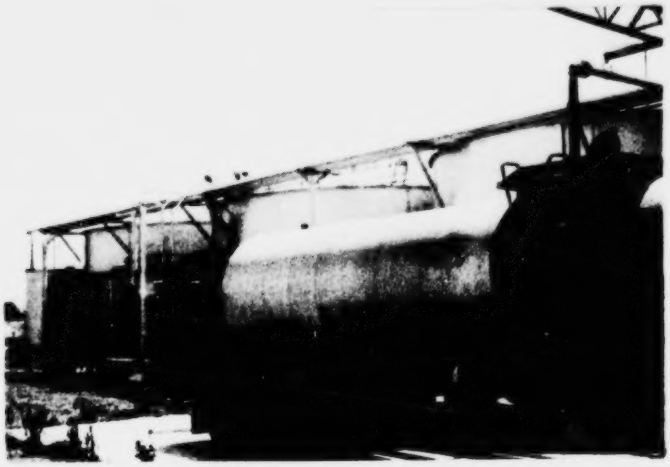
Precise counts on cattle processed were made during three representative month-long sampling periods (see Table II-4). During the 22 working days of the Spring Sampling Period, 13,902 head of cattle were processed. There were 14,420,000 lbs of live weight killed (LWK) or an average of 1,037 lbs LWK per head. Dressed weight was 8,484,000 lbs or 610 lbs per head, with by-products and solid waste accounting for 5,936,000 lbs. On a daily basis, 632 head weighing 656,000 lbs LWK were processed. During the Summer Sampling Period, 939 head were processed daily weighing 996,000 lbs LWK, with an average of 1060 lbs LWK per head. Dressed weight was 607,000 lbs per day or 646 lbs per head per day. During the Winter Sampling Period, 736 head were processed daily weighing 816,000 lbs LWK, with an average of 1109 lb LWK per head. Dressed weight was 466,000 lbs per day or 633 lbs per head per day.

For industrial waste treatment design purposes it was assumed that the quantity and quality of solid waste, by-product, and liquid industrial wasteloads were proportional to that determined during the study period on a per head processed basis, and that future wastes would be affected directly by the number of beef cattle processed.

B. WASTEWATER

1. General

Wastewater at the Swift plant was of two basic types: process and sanitary. The major component was for the process wastewater, consisting of paunch and plant waste, since



II-1. Truck Transfer of Paunch Sludge From Air Flotation Units

II-2. Paunch Waste Pretreated in Air Flotation Unit

TABLE II-4

CATTLE PROCESSING

Study Period	Head	Weight, 1000 lbs		
		Live	Dressed Beef	By-Products and Solid Waste
Spring Sampling				
6/ 2 - 6/ 6	3,076	3,267	1,926	1,341
6/ 9 - 6/13	3,121	3,258	1,909	1,349
6/16 - 6/20	3,168	3,218	1,887	1,331
6/23 - 6/27	3,241	3,348	1,959	1,389
6/30 - 7/ 1	1,296	1,329	803	526
Subtotals	13,902	14,420	8,484	5,936
Daily Average	632	656	386	270
Summer Sampling				
8/25 - 3/29	4,421	4,751	2,936	1,815
9/ 2 - 9/ 5	3,592	3,852	2,316	1,536
9/ 8 - 9/12	4,515	4,787	2,894	1,893
9/15 - 9/19	4,516	4,841	2,922	1,919
9/22 - 9/26	5,481	5,685	3,506	2,179
Subtotals	22,525	23,916	14,574	9,342
Daily Average	939	996	607	389
Winter Sampling				
1/ 5 - 1/ 9	3,548	3,925	2,265	1,660
1/12 - 1/16	3,823	4,300	2,473	1,827
1/19 - 1/23	3,962	4,289	2,458	1,831
1/26 - 1/30	3,383	3,807	2,130	1,677
Subtotals	14,716	16,321	9,326	6,995
Daily Average	736	816	466	350

It carried the significant pollution load. Sanitary wastewater was generated by the boiler and engine room discharges, stockyard washdown, sewage from washrooms, and other miscellaneous uses. The general layout of the plant sewers is shown in Figure II-2.

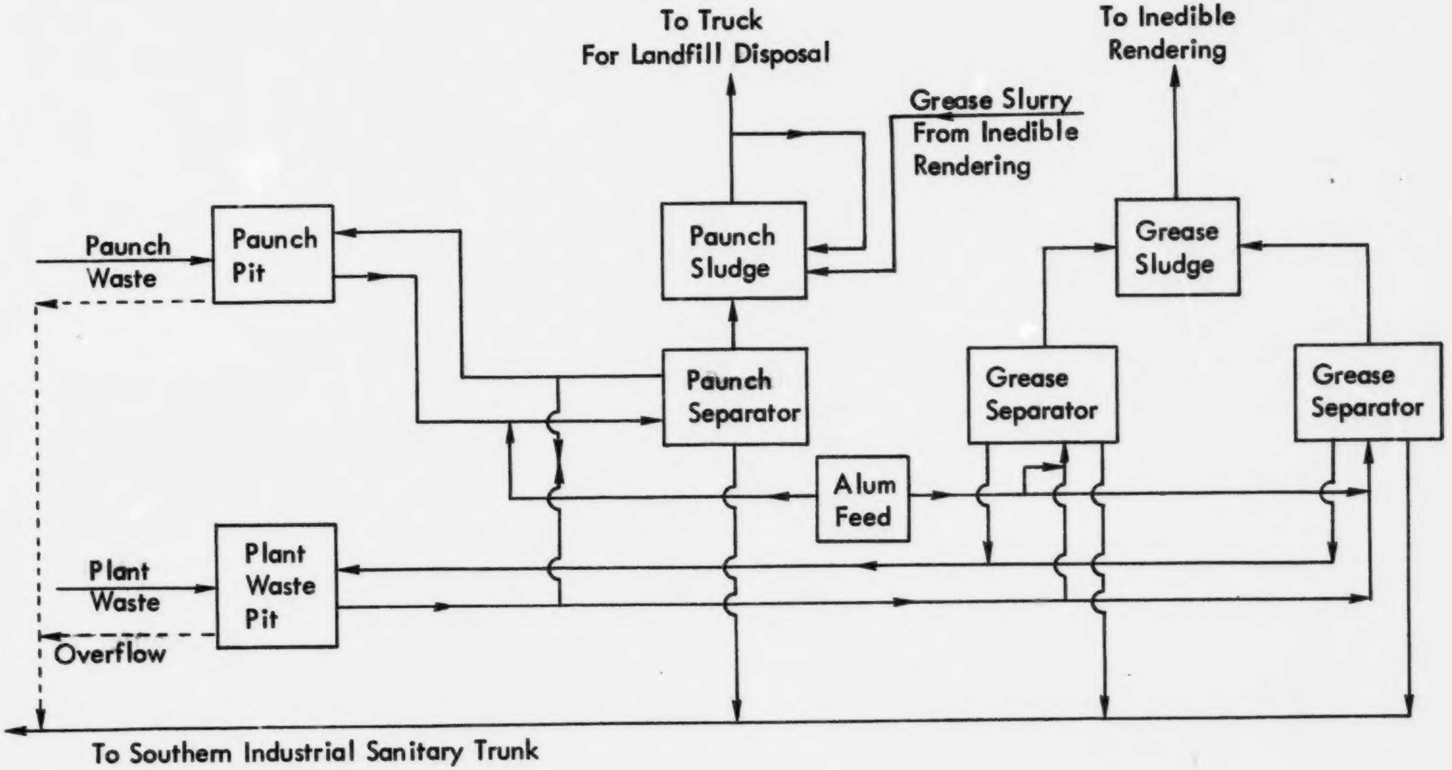
Paunch wastewater consisted of effluent from the paunch dump, umbrella washer, casing separator table and conveyor, and hotwell area; and washdown spillage from the paunch manure bin loading area.

Plant wastewater consisted of all other process water and contained considerably less solids. It was derived from washdown of killing and carcass production, inedible rendering, edible rendering, hide curing, tallow tank, and cooler areas. Most of it came from hand, knife, and saw sterilizing; emptying various tanks; spray showers; and plant clean-up during and after processing.

The paunch waste was carried from the edible and inedible rendering buildings to the "paunch pit" at the existing Swift pretreatment facility. Next to this pit was the "plant waste pit" which received tallow tank wash water and all the other processing plant waste. The paunch and plant wastes were then pumped from the respective pits to the pretreatment flotation units which separated the paunch fines and grease. The pretreated effluent was then discharged into the sewers with the sanitary wastewater. The total plant wastewater discharge was measured and the volume recorded at the Parshall flume before entering the City's Southern Industrial Trunk.

The existing pretreatment plant was made up of the two previously-mentioned pits, three air-flotation tanks, alum feeder, and sludge tanks depicted in Figure II-4 and Photograph II-2. In accordance with standard operating procedure, close to 5:00 P.M. daily the paunch pit and one plant waste air-flotation tank were shut down for the night. They were reactivated at approximately 7:00 A.M. the following morning. During this period, the flows exceeding the capacity of the one operating tank were discharged directly into the sanitary sewer through overflow sewers. Paunch waste also overflowed directly into the sanitary sewer. Each air-flotation tank was emptied and cleaned once a week. The paunch tank and one of the other tanks were usually emptied on Friday afternoons and left empty over the weekend. The other air-flotation tank was usually emptied on Tuesday or on Wednesday evening. An average of 200 lbs per day of alum was fed into the flotation tanks to improve the flotation process.

Sanitary wastewaters are all liquid wastes discharged to the sewer system without pretreatment in the flotation tanks. They were a relatively small flow percentage (about 10 to 15%) of the total plant wastewater. The effluent from washdown of the stockyards and for cooling the cattle contained manure, sand, and dirt. Showers, locker rooms, cafeteria, and other miscellaneous sources discharged typical sanitary sewage. The boiler and engine building effluent consisted of primarily boiler blowdown, water softener regeneration wastes, and cooling tower bleedoff. These sanitary wastewaters were discharged to the sewer downstream of the pretreatment flotation units.


To Truck
For Landfill Disposal
To Inedible
Rendering
Grease Slurry
From Inedible
Rendering
Paunch
Waste
Paunch
Pit
Paunch
Sludge
Grease
Sludge
Paunch
Separator
Grease
Separator
Grease
Separator
Alum
Feed
Plant
Waste
Plant
Waste
Pit
Overflow
To Southern Industrial Sanitary Trunk

City of Stockton
Swift & Co. - FWPCA Project

SWIFT AND COMPANY INDUSTRIAL WASTE PRETREATMENT PROCESS FLOW DIAGRAM

FIGURE II-4

2. Field Sampling Program

The sampling program was designed to determine the characteristics and volumes of Swift industrial wastewater, and its effect on the City of Stockton's sewerage facilities. Three separate one-month-long sampling periods were selected to represent three basic seasonal variables: low-canning dry weather conditions, June 2-July 1, 1969; peak canning season conditions, August 26-September 26, 1969; and non-canning wet weather conditions, January 5-31, 1970. For simple identification these periods are generally referred to in this report as the Spring, Summer, and Winter Sampling Periods, respectively.

The comprehensive field test program was designed to provide significant samples to determine average, maximum, and minimum waste flow and quality characteristics. Grab samples were taken at both random and select times. Since the plant did not operate on weekends and holidays, sampling was limited to weekdays.

Each grab sample was immediately analyzed for characteristics that changed significantly with time. A portion of each grab sample was included in a composited sample analyzed at the finish of each sampling period for stable characteristics. To determine typical waste characteristic changes during the day, representative 24-hour samples and tests were also performed once during each month-long sampling period.

The sampling stations were selected to evaluate critical changes in separate and combined rates and characteristics for the main sources of wastewater. The stations are described in Table II-5, and their locations are shown in Figure II-2. Station S-1 sampling schedule is shown in Table II-6; Stations S-2 through S-8 were sampled consecutively following Station S-1. The time at which the sampling was done at Stations S-2 to S-8 corresponded to the time at which sewage from Station S-1 arrived at the Station in question.

Plant sampling and flow measurements were performed by Swift personnel and recorded on data sheets similar to that shown in Appendix B. The standard sampling procedure was as follows:

a. The sampling dipper and storage jar were rinsed with the sewage to be sampled.

b. The sample was taken (Photographs II-3 and II-4).

c. The wastewater temperature was measured and recorded.

d. The time of sampling was recorded (Photograph II-5).

e. The flow data was measured and recorded by determining the depth of flow at upstream and downstream manholes and the time for floats to travel between manholes (Photograph II-6). Flow calculations were completed by the project engineers.

TABLE II-5

SAMPLE STATION LOCATIONS[1]
SWIFT AND COMPANY

Station No.	Location
S-1	Paunch pit influent at manhole MK-34[2] before pre-treatment
S-2	Plant waste pit influent at manhole MK-32[2] before pre-treatment
S-3	Paunch separator tank effluent at weir
S-4A	First plant waste separator tank effluent at weir
S-4B	Second plant waste separator tank effluent at weir
S-5	Combined separator tank effluent from 18-in. inlet channel to manhole MK-2[2]
S-6	Boiler and engine building wastewater from 8-in. inlet channel to manhole MK-2[2]
S-7	Sanitary sewage and manure washdown wastewater from 15-in. outlet channel to manhole MK-6[2]
S-8	Parshall Flume

[1] See Figure II-2 for location of sample stations.

[2] Manhole designation per Drawing No. V-03-15-65-001, Swift and Company.

TABLE II-6

SAMPLING SCHEDULE FOR STATION S-1[1]
SWIFT AND COMPANY

Spring (June 1969)		Summer (August-September 1969)		Winter (January 1970)	
Time	Date	Time	Date	Time	Date
1:00 P.M.	2[2]	8:00 A.M.	26[2]	10:00 A.M.	5
3:00 P.M.	3	3:00 P.M.	26	2:00 P.M.	5
1:00 P.M.	4	1:00 P.M.	27	1:00 A.M.	6
2:00 A.M.	5	2:00 A.M.	28	12:00 Midnight	6
5:00 A.M.	5	5:00 A.M.	28	2:00 A.M.	8[2]
5:00 A.M.	10	5:00 A.M.	2	5:00 A.M.	8
8:00 A.M.	10	9:00 A.M.	2	11:00 A.M.	13
11:00 A.M.	11	12:00 Noon	3	7:00 A.M.	16[2]
12:00 Noon	12	12:00 Noon	4	11:00 A.M.	20
2:00 A.M.	14	12:00 Midnight	5	3:00 A.M.	21
8:00 A.M.	17	6:00 P.M.	11	6:00 A.M.	21
4:00 P.M.	18	10:00 P.M.	15	11:00 A.M.	21
6:00 P.M.	19	5:00 P.M.	16	4:00 P.M.	21
1:00 A.M.	20	12:00 Midnight	17	11:00 A.M.	23
12:00 Midnight	23	1:00 A.M.	22	11:00 A.M.	26
11:00 A.M.	24	11:00 P.M.	22	12:00 Noon	26
5:00 P.M.	24	2:00 A.M.	23	11:00 P.M.	27
10:00 A.M.	27	1:00 P.M.	23	2:00 P.M.	28
12:00 Midnight	29			11:00 P.M.	28
12:00 Midnight	30			3:00 A.M.	30
				7:00 A.M.	30
				3:00 A.M.	31
Total Samples: 20		Total Samples: 18		Total Samples: 22	

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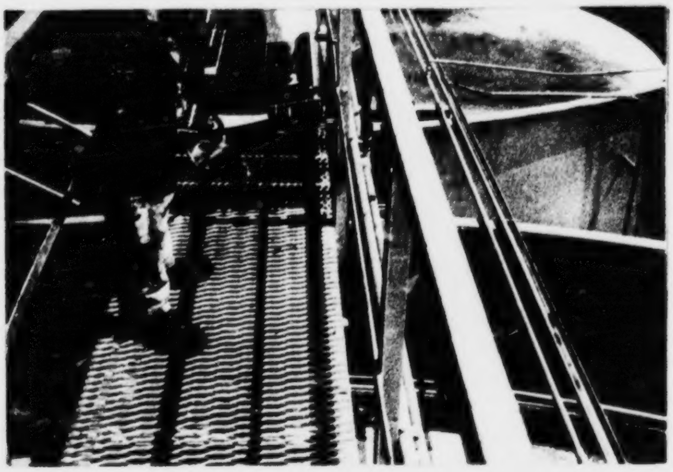
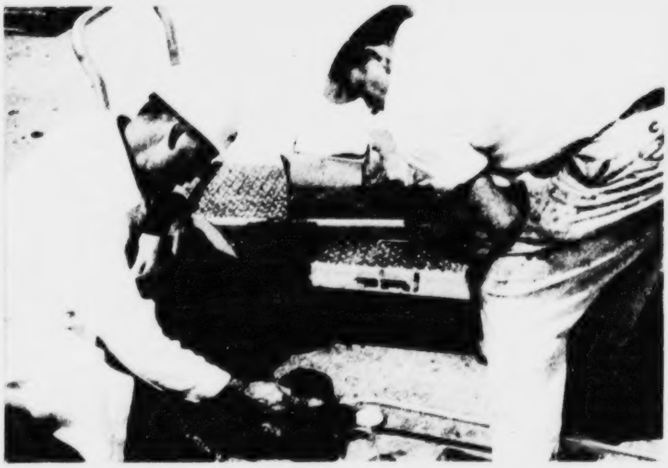
[1] Stations S-2 through S-8 were sampled consecutively following S-1.

[2] 24-hour sampling program performed.



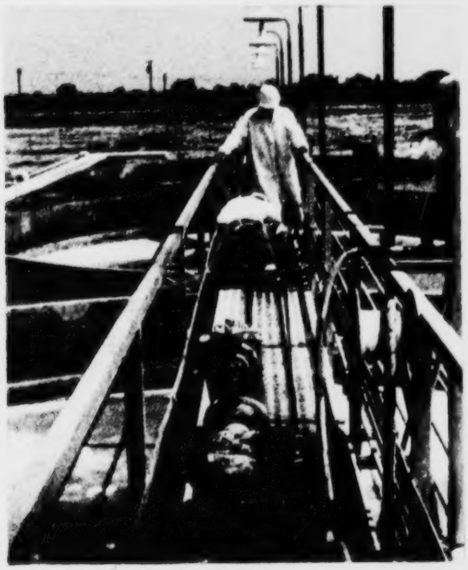
II-3. Sampling Treated Effluent at Weir of Air Flotation Tank



II-4. Waste Sampling at Station S-2

City of Stockton
Swift & Co. - FWPCA Project

PHOTOGRAPHS



II-5. Recording Data During Sampling of Air Flotation Effluent

II-6. Timing Sewer Flow at Station S-1 Influent to Paunch Pit

All samples were stored in cold storage vaults. They were picked up daily by City of Stockton personnel and delivered to the City's Main Water Quality Plant for analysis.

3. Analytic Procedure

Analysis of all field samples was normally done in the City of Stockton's laboratory at the Main Water Quality Plant. Sample storage procedures conformed to "Standard Methods for the Examination of Waste and Wastewater", Twelfth Edition. Samples collected during the 24-hour test period at Swift were analyzed for the following chemical and physical properties: pH, BOD, COD, grease, specific electrical conductance, total dissolved solids, settleable solids, ammonia, total Kjeldahl nitrogen, and total phosphate. All BOD analyses refer to biochemical oxygen demand. The daily samples collected during the month-long period were promptly analyzed for pH, BOD, COD, grease, specific electrical conductance, total solids, suspended solids, and settleable solids.

A composite sample was made at each Swift station during the sampling period. Equal portions of daily samples from each station were combined. The composite samples were then analyzed for the following: pH, total hardness, alkalinity, grease, specific electrical conductivity, total, fixed, volatile, suspended, settleable, and dissolved solids; nitrate; nitrites; ammonia; total Kjeldahl nitrogen; calcium; magnesium; sodium; potassium; sulfate; chloride; total phosphate; and iron.

At the Parshall flume station, a recorder maintained continuous graphic flowrate records. The flume was found to be inaccurate because the controller and chart were not properly calibrated. Flowrates were then calculated on the basis of the average flow depths and velocities in the sewers from:

$$Q = \frac{L}{t}\left(\frac{A_u + A_d}{2}\right)$$

Where Q = average flow

L = distance from station u to station d

t = time for a floating object to travel a distance L

A_u = cross-sectional area of flow at station u

A_d = cross-sectional area of flow at station d

4. Characteristics

The average, maximum, and minimum plant wastewater characteristics for the Spring Sampling Period, based on 24-hour grab samples, month-long grab samples, and month-long composites, are presented in Tables II-7, II-8, and II-9, respectively. The Summer and Winter Sampling Periods data is presented in Tables II-10 to II-12 and Tables II-13 to II-15, respectively. The Tables also include data from key samplings of the Southern Industrial Trunk and the Main Water Quality Plant, which is described in Sections III and IV. Tables II-16 and II-17 present summaries of the characteristics of Swift effluent for the aforementioned three sampling periods.

The Parhsall flume (Station S-8) indicated flows of about 1.0 mgd during both the Spring and Summer Periods. These flows compared within 10 to 20 percent of the measured discharges at Stations S-2 and S-5 to S-7. However, these wastewater discharges were about 50 percent less than the water used, as indicated in Table II-2. Reportedly, there were only minor losses of water in plant processes. The steam and evaporation losses were estimated by City authorities to be about 2 to 10 percent of the total water used.

An average flow of 1.61 mgd was measured manually during the 24-hour Winter Sampling Period; this corresponded to the water use records and to the upstream flows measured and calculated for Stations S-1, S-2, and S-5 to S-7. The flowrates were determined by measuring the depth of flow in the Parshall flume and using the equation $Q = 4.1\ WH^{3/2}$.

Where Q = flowrate in cfs

W = throat width in ft

H = height of flow at a point 2/3 the distance from throat to beginning of constriction

The comparable flows recorded on the 7-day chart averaged 0.95 mgd, 41 percent less than the manually measured and calculated flows.

Hourly flowrates recorded during the three study periods are shown in Figures II-5 to II-7. In addition, Figure II-7 shows the manually-measured flows. Hence, the actual flows were about 40 percent higher than those recorded by the Parshall flume. The Parshall flume recorded flow data graphically and indicated the rapid increase in discharge between 5:00 and 7:00 A.M., from less than 0.3 mgd to more than 1.0 mgd. The flowrate fluctuated between 1.0 and 1.9 mgd until plant clean-up tapered off; then the flowrate decreased to a nominal level of 0.1 to 0.5 mgd. The time when the flowrate dropped off varied with the number of cattle processed and duration of processing. For example, in June 1969, when about 600 cattle were processed daily, the discharge dropped to less than 1.0 mgd at about 5:00 P.M. In August and September

TABLE II-7

ANALYSIS OF GRAB SAMPLES FROM 24-HOUR STUDY, SPRING 1969

Station	Flowrate, MGD			Temperature, °F			pH			BOD mg/1			Chemical Oxygen Demand mg/1		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	0.42	0.60	0.06	100	122	78	6.0	7.00	6.4	1,652	2,050	480	970	2,280	158
S-2	0.61	1.20	0.20	91	101	83	7.6	9.20	6.4	294	780	60	210	450	49
S-3	--	--	--	101	110	94	6.2	6.40	5.8	1,170	1,560	900	666	1,050	405
S-4A	--	--	--	92	110	82	6.8	7.30	6.3	1,380	2,040	540	538	860	224
S-4B	--	--	--	92	93	92	7.0	7.10	6.9	615	960	180	313	396	224
S-5	0.98[1]	2.10[1]	0.47[1]	91	94	86	6.0	7.10	6.3	960	2,040	180	440	850	210
S-6	0.12	0.33	0.06	81	85	78	9.3	9.50	6.3	37	2,040	0	61	1,270	0
S-7	0.10	0.44	0.00	71	77	66	8.0	8.80	7.3	404	1,740	60	613	1,500	70
S-8[3]	0.84	1.60[4]	0.25	--	--	--	6.9	7.20	6.6	1,308	2,160	720	528	880	380

TABLE II-7 (Continued)

ANALYSIS OF GRAB SAMPLES FROM 24-HOUR STUDY, SPRING 1969

Station	Grease, mg/l			Specific Electrical Conductance, micromhos/cm			Total Solids, mg/l			Suspended Solids mg/l			Settleable Solids, mg/l		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	490	989	50	1,319	1,670	385	2,574	6,380	828	1,171	5,904	180	2.50	15	TR
S-2	173	487	26	1,445	3,210	758	1,452	2,684	812	584	1,676	160	0.50	5	TR
S-3	264	470	68	1,541	1,670	1,284	2,265	2,976	1,424	348	592	208	TR	TR	TR
S-4A	394	943	30	1,514	2,120	1,150	1,955	2,916	1,248	480	1,100	168	0.50	5	TR
S-4B	292	665	66	1,411	1,860	1,090	1,719	2,336	1,384	314	452	224	1.25	5	TR
S-5	380	1,209	16	1,448	3,060	1,155	1,644	3,584	420	414	820	156	0.50	5	TR
S-6	126	994	1	420	1,285	337	357	1,624	120	195	332	64	TR	TR	TR
S-7	231	1,576	5	836	1,540	450	1,500	3,304	280	789	1,720	280	30.50	80	TR
S-8[3]	256	799	35	1,490	2,050	990	1,748	2,976	636	565	1,454	196	3.10	20	TR

TABLE II-7 (Continued)

ANALYSIS OF GRAB SAMPLES FROM 24-HOUR STUDY, SPRING 1969, in mg/l

Station	Ammonia (NH_3)			Organic Nitrogen [2]	Total Kjeldahl Nitrogen (N)			Total Phosphate (PO_4)		
	avg	max	min		avg	max	min	avg	max	min
S-1	44	130	12	33	77	131	12	20	35	9
S-2	11	18	6	20	31	97	10	9	30	2
S-3	45	49	39	34	79	87	74	35	45	26
S-4A	21	49	7	34	55	106	19	16	38	9
S-4B	17	29	6	15	32	53	13	14	18	11
S-5	22	43	12	44	66	184	23	18	43	12
S-6	2	5	0	2	4	12	0	3	5	1
S-7	43	158	12	23	66	199	19	28	66	7
S-8[3]	39	116	7	22	61	148	14	23	37	10

[1] Flowrate is sum of treated effluent (S-5) and boiler and engine building effluent (S-6).

[2] Calculated based on the average ammonia and average total Kjeldahl nitrogen.

[3] Twenty-two samples taken during period.

[4] Excludes 20-minute-long peak discharges 3 times a week when the flotation tanks were emptied. Rates ranged up to 2.5 mgd.

TABLE II-8

ANALYSIS OF GRAB SAMPLES FROM MONTH-LONG STUDY, SPRING 1969

Station	Flowrate, mgd			Temperature °F			pH			BOD mg/1			Chemical Oxygen Demand, mg/1			Sulfides mg/1		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	0.45	0.70	0.02	92	112	76	7.0	7.3	6.1	1,530	3,140	0	990	2,557	40	--	--	--
S-2	0.80	2.44	0.07	92	97	78	8.2	10.7	6.9	595	>2,220	61	525	4,000	44	--	--	--
S-3	--	--	--	98	106	87	6.7	7.0	6.5	1,339	1,920	840	820	1,185	424	--	--	--
S-4A	--	--	--	92	103	82	7.4	9.3	6.8	1,320	3,300	360	630	1,225	330	--	--	--
S-4B	--	--	--	93	98	91	7.2	8.3	6.7	945	1,300	660	468	675	330	--	--	--
S-5	0.59[1]	1.39[1]	0.23[1]	95	116	80	7.3	8.8	6.1	776	>2,220	0	625	2,700	49	--	--	--
S-6	0.11	0.26	0.06	86	130	70	8.9	9.6	8.0	21	60	0	8	22	0	--	--	--
S-7	0.10	0.32	0.02	74	88	62	8.4	8.9	7.7	429	1,080	0	934	3,300	40	--	--	--
S-8	1.08	1.80[2]	0.32	87	94	70	7.6	8.5	7.0	773	1,320	240	595	888	182	--	--	--
S-9	2.25	4.49	0.71	87	105	80	6.9	7.3	6.5	486	> 760	100	319	613	101	1.4	2.2	0.6
S-10	2.32	3.56	1.17	84	93	75	6.9	7.3	6.7	414	770	140	278	493	106	1.6	3.3	0.1
S-11	--	--	--	--	--	--	6.8	7.4	5.9	288	700	140	270	408	155	1.3	2.6	0.2
S-12	--	--	--	--	--	--	6.5	6.5	6.5	340	340	340	200	200	200	--	--	--
S-13	--	--	--	--	--	--	6.7	7.4	6.4	193	290	72	157	258	88	--	--	--
S-14	--	--	--	--	--	--	7.5	8.1	7.1	72	126	18	125	178	67	--	--	--
S-15	--	--	--	--	--	--	7.5	8.5	7.1	53	84	18	102	160	40	--	--	--

TABLE II-8 (Continued)

ANALYSIS OF GRAB SAMPLES FROM MONTH-LONG STUDY, SPRING 1969

Station	Grease, mg/l			Specific Elec. Conductance, micromhos/cm			Total Solids, mg/l			Suspended Solids mg/l			Settleable Solids mg/l		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	495	1,693	35	1,282	3,150	257	2,542	4,136	300	926	1,932	200	13	30	TR
S-2	861	9,263	31	2,042	7,710	667	2,742	15,428	840	935	8,012	64	6	20	TR
S-3	469	1,875	102	1,570	2,060	1,090	2,104	2,672	1,436	470	640	304	7	10	5
S-4A	276	1,174	27	1,780	4,820	1,025	2,160	3,872	372	475	1,120	76	5	10	5
S-4B	450	1,560	77	2,026	4,820	1,060	2,038	3,896	1,404	376	548	80	4	5	TR
S-5	419	2,927	9	1,545	3,960	515	2,032	9,252	516	516	4,164	24	7	40	TR
S-6	248	1,413	1	340	409	282	244	504	156	83	260	3	TR	TR	TR
S-7	230	1,743	3	1,417	2,820	348	2,024	3,744	196	805	1,996	15	18	40	TR
S-8	103	177	63	1,297	1,620	1,000	1,520	1,788	964	380	548	185	8	10	TR
S-9	123	613	7	1,336	6,280	564	1,482	5,800	524	422	956	64	8	10	5
S-10	172	645	4	1,128	2,050	610	1,154	1,788	528	399	916	101	10	20	5
S-11	78	239	1	1,087	1,285	885	932	1,228	624	313	884	88	12	30	5
S-12	--	--	--	1,260	1,260	1,260	1,092	1,092	1,092	806	806	806	10	10	10
S-13	62	630	1	1,148	1,350	823	799	964	660	195	752	6	TR	5	TR
S-14	15	42	1	1,145	1,285	965	753	896	616	176	692	7	5	5	0.5
S-15	60	734	1	1,163	1,348	834	721	1,092	372	162	752	4	TR	5	TR

TABLE II-8 (Continued)

ANALYSIS OF GRAB SAMPLES FROM MONTH-LONG STUDY, SPRING 1969

[1] Flowrate is sum of treated effluent (S-5) and the boiler and engine building effluent (S-6).

[2] Excludes 20-minute-long peak discharges 3 times a week when the flotation tanks were emptied. Rates then ranged up to 2.5 mgd.

TABLE II-9

ANALYSIS OF COMPOSITE SAMPLES FROM MONTH-LONG STUDY, SPRING 1969

Station	pH	Total Hardness ($CaCO_3$) mg/1	Total Alkalinity ($CaCO_3$) mg/1	Grease mg/1	Specific Electrical Conductance micromhos/cm	Total Solids mg/1	Fixed Solids mg/1	Volatile Solids mg/1	Suspended Solids mg/1	Settleable Solids mg/1	Dissolved Solids mg/1
S-1	6.7	80	370	425	1,270	2,235	458	1,777	1,120	3.0	1,115
S-2	6.7	20	250	357	1,800	2,302	865	1,437	866	1.5	1,436
S-3	6.9	20	270	197	1,280	1,743	524	1,219	700	1.0	1,043
S-4A	6.7	20	235	218	1,480	1,796	647	1,149	505	0.6	1,291
S-4B	7.1	42	205	139	1,670	1,543	613	930	402	0.2	1,141
S-5	6.7	20	240	199	1,475	1,774	557	1,217	583	5.5	1,191
S-6	7.3	28	133	20	334	252	171	81	44	TR	208
S-7	7.3	120	780	43	1,780	2,036	650	1,386	1,003	20	1,033
S-8	7.0	20	280	133	1,155	1,495	395	1,100	494	4.5	1,001
S-9	6.6	60	265	105	1,285	1,280	433	847	382	6.0	898
S-10	6.7	60	270	70	1,155	1,092	388	704	344	4.5	748
S-11	6.7	138	220	88	1,025	900	393	507	208	9.0	692
S-13	6.8	162	240	65	1,065	788	362	426	102	TR	686
S-14	7.2	158	230	44	1,155	775	416	359	127	0.5	648
S-15	7.2	154	245	33	1,180	714	327	387	87	0.5	627

TABLE II-9 (Continued)

ANALYSIS OF COMPOSITE SAMPLES FROM MONTH-LONG STUDY, SPRING 1969, in mg/l

Station	Ammonia (NH_3)	Organic Nitrogen (N)	Total Kjeldahl Nitrogen (N)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Total Phosphate (PO_4)	Iron (Fe)
S-1	42	26	68	26	4	260	36	25	200	59	0.14
S-2	13	27	40	8	TR	460	17	15	530	21	0.07
S-3	27	36	63	8	TR	215	30	40	260	42	0.14
S-4A	17	13	40	8	TR	350	10	35	380	14	0.06
S-4B	9	19	28	11	4	350	10	5	450	14	0.08
S-5	26	11	37	8	TR	300	10	5	400	21	0.11
S-6	0	<1	<1	11	TR	100	5	5	135	5	0.18
S-7	123	15	139	48	TR	135	92	25	140	44	0.22
S-8	27	7	34	8	TR	195	20	20	265	22	0.12
S-9	27	3	30	24	TR	225	13	20	320	18	0.12
S-10	24	4	28	24	TR	210	14	20	270	17	0.11
S-11	12	1	13	55	TR	135	13	20	235	17	0.07
S-13	10	<1	10	65	TR	165	13	20	235	18	0.18
S-14	12	<1	13	63	TR	165	12	25	255	18	0.12
S-15	13	0	13	62	TR	155	13	15	250	16	0.12

TABLE II-10

ANALYSIS OF GRAB SAMPLES FROM 24-HOUR STUDY, SUMMER 1969

Sta-tion	Flowrate, mgd			Temperature, °F			pH			BOD mg/1			Chemical Oxygen Demand mg/1		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	0.35	0.71	0	99	130	84	7.0	7.9	5.9	1,278	3,480	480	1,640	3,880	44
S-2	0.53	0.93	0.14	92	108	82	7.7	8.9	7.0	682	1,560	120	386	616	0
S-3[1]	--	--	--	104	108	101	6.8	7.0	6.7	1,467	1,920	780	1,104	1,200	950
S-4A	--	--	--	91	100	80	7.3	8.1	6.8	1,120	2,400	60	778	1,782	352
S-4B[2]	--	--	--	--	98	--	--	7.6	--	--	1,300	--	--	1,040	--
S-5	0.98[3]	1.68[3]	0.42[3]	90	102	80	7.1	7.7	6.1	880	1,920	60	614	1,126	202
S-6	0.15	0.24	0.07	76	79	71	9.4	10.0	8.8	14	55	0	35	80	0
S-7	0.12	0.36	0	80	88	72	8.3	9.0	7.5	599	1,620	60	1,312	3,652	44
S-8	1.10	1.90	0	87	96	80	7.2	7.9	6.7	787	1,560	420	699	1,267	387

TABLE II-10 (Continued)

ANALYSIS OF GRAB SAMPLES FROM 24-HOUR STUDY, SUMMER 1969

Station	Grease, mg/l			Specific Elec. Conductance, micromhos/cm			Total Solids, mg/l			Suspended Solids mg/l			Settleable Solids, mg/l		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	899	5,120	21	1,736	2,824	282	3,281	10,618	366	1,140	3,084	96	14	50	TR
S-2	942	6,689	8	1,624	2,820	932	1,554	2,522	128	546	1,356	88	1	5	TR
S-3	219	254	188	2,420	2,502	2,318	2,736	2,870	2,516	599	688	432	4	10	1
S-4A	133	322	15	2,410	3,820	1,478	2,458	3,900	1,462	537	1,020	68	3	10	TR
S-4B	--	194	--	--	1,670	--	--	2,128	--	--	448	--	--	TR	--
S-5	140	485	5	1,917	3,180	1,030	1,757	2,598	272	247	560	20	2	5	TR
S-6	>1	>1	0	410	592	334	320	414	270	127	272	5	TR	TR	TR
S-7	38	68	0	1,875	5,790	358	2,179	4,704	288	621	1,340	112	4	10	0
S-8	244	681	26	1,396	2,180	257	1,839	2,872	842	508	1,262	51	4	10	TR

TABLE II-10 (Continued)

ANALYSIS OF GRAB SAMPLES FROM 24-HOUR STUDY, SUMMER 1969

Station	Ammonia (NH_3)			Organic[4] Nitrogen	Total Kjeldahl Nitrogen (N)			Total Phosphate (PO_4)		
	avg	max	min		avg	max	min	avg	max	min
S-1	48	140	4	17	65	165	8	48	205	6
S-2	9	22	0	18	27	76	3	11	29	1
S-3	38	56	18	41	79	127	25	24	32	16
S-4A	13	25	0	—	37	97	14	10	18	2
S-4B	--	16	--	--	--	22	--	--	2	--
S-5	20	56	6	23	43	112	15	8	17	4
S-6	0	0	0	1	1	5	0	4	9	3
S-7	155	589	5	66	221	714	10	19	40	4
S-8	22	45	1	15	37	84	1	16	30	3

[1] 3 observations only.

[2] 1 observation only.

[3] Flowrate is combined treated effluent (S-5) and boiler and engine building effluent (S-6).

[4] Calculated based on the average ammonia and average total Kjeldahl nitrogen.

TABLE II-11

ANALYSIS OF GRAB SAMPLES FROM MONTH-LONG STUDY, SUMMER 1969

Station	Flowrate, mgd			Temperature °F			pH			BOD mg/1			Chemical Oxygen Demand, mg/1			Sulfides mg/1		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	0.34	1.06	0	96	108	80	7.2	9.2	5.9	1,490	3,480	197	923	3,432	167	—	—	—
S-2	0.55	1.43	0.14	92	105	68	7.7	9.6	6.6	684	2,800	12	335	845	18	—	—	—
S-3	—	—	—	104	110	98	6.7	7.1	6.1	1,227	2,000	392	769	1,161	343	—	—	—
S-4A	—	—	—	97	104	90	6.7	7.6	6.2	1,350	2,400	204	662	1,373	150	—	—	—
S-4B	—	—	—	92	104	78	7.1	8.6	6.1	940	1,960	69	559	1,496	88	—	—	—
S-5	0.90[1]	2.03[1]	0.16[1]	92	104	70	7.3	9.8	6.1	816	1,960	28	474	1,373	66	—	—	—
S-6	0.21	0.45	0.08	78	100	70	8.8	9.6	7.6	22	80	0	39	242	0	—	—	—
S-7	0.11	0.36	0	77	80	70	8.2	9.0	7.5	491	1,512	56	1,173	4,752	207	—	—	—
S-8	1.05	1.50	0.03	88	98	78	7.3	9.4	6.2	696	1,400	12	415	880	13	—	—	—
S-9	2.83	6.28	0.67	84	92	78	6.9	9.4	6.1	647	1,232	112	413	739	70	1.4	4.0	TR
S-10	7.24	10.07	3.57	80	93	65	6.5	11.3	5.4	387	784	112	316	792	110	1.4	3.0	TR
S-11	—	—	—	82	84	81	7.9	10.5	6.5	469	690	315	351	678	60	0.4	1.0	0
S-13	—	—	—	83	86	82	6.7	7.2	5.3	346	540	180	201	299	139	—	—	—
S-14	—	—	—	82	82	81	7.2	7.5	6.2	226	396	132	170	312	56	—	—	—
S-15	—	—	—	83	86	81	7.0	7.4	6.7	206	324	132	169	273	80	—	—	—
S-16	—	—	—	76	77	73	8.3	8.8	7.8	24	34	13	154	205	41	—	—	—

[1] Flowrate is combined treated effluent (S-5) and boiler and engine building effluent (S-6).

TABLE II-11 (Continued)

ANALYSIS OF GRAB SAMPLES FROM MONTH-LONG STUDY, SUMMER 1969

Station	Grease, mg/l			Specific Elec. Conductance, micromhos/cm			Total Solids, mg/l			Suspended Solids mg/l			Settleable Solids, mg/l		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	487	1,276	2	1,662	2,824	591	3,245	6,888	844	1,055	3,844	52	11	45	TR
S-2	204	876	0	1,500	3,080	416	1,987	4,734	336	443	1,438	46	20	10	TR
S-3	163	296	45	1,890	2,440	759	2,425	3,130	1,334	446	1,064	48	1	2	TR
S-4A	213	375	1	1,833	3,218	900	2,502	3,900	794	560	1,020	38	3	10	TR
S-4B	259	929	7	2,004	3,220	488	2,489	4,174	478	352	834	31	3	19	TR
S-5	250	1,991	0	2,140	10,300	417	2,422	7,654	336	475	2,686	17	3	30	TR
S-6	TR	2	0	347	450	218	275	354	140	107	509	7	TR	TR	0
S-7	42	111	5	1,186	2,370	411	2,928	10,772	566	997	2,480	228	23	100	TR
S-8	127	448	0	1,462	2,640	295	1,673	3,274	270	380	822	13	1	5	TR
S-9	88	275	1	1,195	1,989	437	1,367	2,272	400	355	1,040	33	2	5	TR
S-10	40	109	1	836	2,440	386	1,168	2,004	592	405	762	139	6	40	TR
S-11	27	66	2	947	1,030	835	1,331	1,546	1,155	362	484	270	27	37	20
S-13	9	21	1	952	1,030	835	1,028	1,228	928	108	215	33	>1	3	TR
S-14	9	32	1	1,011	1,160	785	1,061	1,252	898	152	320	56	2	4	TR
S-15	7	22	1	1,043	1,220	795	950	1,144	812	82	127	28	TR	TR	TR
S-16	1	5	0	1,111	1,350	1,030	865	900	812	102	152	51	TR	TR	TR

TABLE II-12

ANALYSIS OF COMPOSITE SAMPLES FROM MONTH-LONG STUDY, SUMMER 1969

Station	pH	Total Hardness ($CaCO_3$) mg/l	Total Alkalinity ($CaCO_3$) mg/l	Grease mg/l	Specific Electrical Conductance micromhos/cm	Total Solids mg/l	Fixed Solids mg/l	Volatile Solids mg/l	Suspended Solids mg/l	Settleable Solids mg/l	Dissolved Solids mg/l
S-1	6.5	20	600	1,664	1,412	2,787	1,204	1,583	1,242	10	1,545
S-2	6.5	20	400	1,164	1,480	2,020	1,065	955	648	10	1,372
S-3	6.8	20	395	130	1,530	2,331	1,293	1,038	520	2	1,811
S-4A	6.5	20	315	170	1,350	2,046	1,087	959	542	7	1,504
S-4B	6.8	30	370	234	1,670	2,433	1,485	948	586	4	1,847
S-5	6.8	30	315	143	1,542	2,397	1,324	1,073	520	8	1,877
S-6	7.6	40	230	2	1,250	1,086	958	128	14	TR	1,072
S-7	7.3	100	815	39	1,220	2,398	798	1,600	1,228	31	1,170
S-8	6.9	50	400	114	1,350	1,569	1,001	568	504	5	1,065
S-9	6.7	50	365	57	1,185	1,524	931	593	272	3	1,252
S-10	6.7	60	330	44	782	1,007	790	217	320	3	687
S-11	6.8	140	370	101	962	1,089	626	463	296	12	793
S-13	6.7	140	405	37	898	980	637	343	54	2	926
S-14	7.1	150	405	40	898	962	594	368	86	3	876
S-15	7.0	140	390	19	1,000	910	630	280	24	0.5	886
S-16	7.5	160	360	3	925	866	596	270	63	0.2	803

TABLE II-12 (Continued)

ANALYSIS OF COMPOSITE SAMPLES FROM MONTH-LONG STUDY, SUMMER 1969, in mg/1

Station	Ammonia (NH_3)	Organic Nitrogen (N)	Total Kjeldahl Nitrogen (N)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Total Phosphate (PO_4)	Iron (Fe)
S-1	14	39	53	TR	5	460	33	13	475	42	0.08
S-2	11	22	34	4	2	410	6	15	465	8	0.10
S-3	28	25	53	4	2	440	39	35	540	46	0.02
S-4A	25	22	48	4	2	410	13	28	540	14	0.10
S-4B	28	20	48	4	20	480	11	32	690	14	0.35
S-5	30	20	50	12	TR	490	13	23	770	8	0.18
S-6	0	0	TR	16	TR	330	3	14	420	6	0.01
S-7	123	28	151	12	17	90	80	23	150	51	0.40
S-8	33	14	48	20	TR	330	15	25	460	12	0.24
S-9	28	13	41	12	5	260	14	30	340	18	0.75
S-10	11	7	18	8	10	140	23	19	190	7	0.84
S-11	1	4	5	3	12	190	26	20	215	5	0.36
S-13	4	2	6	36	12	175	26	33	200	6	0.36
S-14	12	3	16	40	12	180	26	25	215	6	0.33
S-15	15	3	18	32	14	180	26	25	215	6	0.23
S-16	10	2	12	60	2	180	23	23	255	6	0.06

TABLE II-13

ANALYSIS OF GRAB SAMPLES FROM 24-HOUR STUDY, WINTER 1969-70

Sta-tion	Flowrate, mgd			Temperature, °F			pH			BOD mg/1			Chemical Oxygen Demand mg/1		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	0.43	0.78	0.0	89	102	72	6.3	6.8	5.8	1,554	2,690	360	1,738	2,600	496
S-2	0.72	1.36	0.15	88	112	74	7.0	10.4	6.1	1,024	4,470	0	1,611	10,252	88
S-3	--	--	--	88	96	84	6.0	6.1	5.8	1,428	2,240	960	2,672	6,500	1,408
S-4A	--	--	--	87	90	80	6.2	6.8	5.6	1,253	2,520	449	1,304	2,130	810
S-4B	--	--	--	87	90	78	6.4	7.5	6.1	711	1,058	447	892	1,468	264
S-5	1.41[1]	2.26[1]	0.89[1]	83	90	70	6.3	6.9	5.7	1,148	2,460	240	1,210	2,170	340
S-6	0.14	0.26	0.08	71	76	62	8.8	9.0	8.2	34	240	6	96	460	0
S-7	0.07	0.20	0.00	55	62	52	8.4	8.9	7.1	1,064	3,010	360	1,469	3,500	114
S-8[3]	0.95[4]	1.70[4,5]	0.25[4]	--	--	--	6.9	7.2	6.7	689	1,320	240	925	1,628	200
S-8[6]	0.92[7]	1.60[5,7]	0.30[7]	--	--	--	7.1	7.8	6.7	1,063	2,405	443	1,592	2,341	766

TABLE II-13 (Continued)

ANALYSIS OF GRAB SAMPLES FROM 24-HOUR STUDY, WINTER 1969-70

Station	Specific Elec. Conductance, micromhos/cm			Total Solids mg/1			Suspended Solids mg/1			Settleable Solids mg/1		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	1,353	1,925	346	2,536	3,896	728	1,178	2,008	172	10	35	1
S-2	2,675	5,800	900	2,931	12,172	416	474	1,896	28	8	40	TR
S-3	1,799	2,060	1,540	2,435	3,084	1,720	863	1,692	240	8	30	1
S-4A	1,992	3,600	385	2,686	3,416	1,828	616	1,600	128	10	40	1
S-4B	2,234	3,850	1,250	2,413	3,436	1,276	504	1,020	112	4	10	TR
S-5	2,330	3,590	1,185	2,670	5,244	1,428	449	964	128	6	25	TR
S-6	444	745	372	297	740	96	113	456	24	TR	TR	TR
S-7	3,254	7,700	1,490	4,451	12,224	1,780	2,216	7,364	412	51	200	2
S-8[3]	2,158	4,170	1,412	1,693	2,856	928	449	936	204	7	20	TR
S-8[6]	1,506	2,320	1,060	3,196	6,420	1,920	975	2,216	304	39	200	4

TABLE II-13 (Continued)

ANALYSIS OF GRAB SAMPLES FROM 24-HOUR STUDY, WINTER 1969-70, in mg/1

Station	Ammonia (NH_3)			Organic[2] Nitrogen	Total Kjeldahl Nitrogen (N)			Total Phosphate (PO_4)		
	avg	max	min[2]		avg	max	min	avg	max	min
S-1	59	101	17	35	94	186	30	95	272	5
S-2	31	140	4	7	38	82	7	41	250	2
S-3	79	112	56	35	114	140	92	127	230	46
S-4A	56	84	14	22	78	114	39	27	62	13
S-4B	47	115	17	19	66	146	33	32	56	19
S-5	66	118	34	30	96	210	26	28	66	8
S-6	1	5	0	0	1	5	0	58	184	4
S-7	343	896	126	60	403	1,053	185	55	88	10
S-8[3]	83	123	56	30	113	157	70	34	62	10
S-8[6]	44	64	28	24	68	106	42	40	72	17

[1] Flowrate is sum of treated effluent (S-5) and boiler and engine building effluent (S-6).

[2] Calculated based on the average ammonia and average total Kjeldahl nitrogen.

[3] Sixteen samples taken during 1/7-8/70 period.

[4] Flows recorded on 7-day chart. Measured flows, based on depth and calibration curve, ranged from 0.40 to 2.20 mgd and averaged 1.38 mgd.

[5] Excludes 20-minute long peak discharges 3 times a week when the flotation tanks were emptied.

[6] Twenty-two samples taken during 1/15-16/70 period.

[7] Recorded flows. Computed flows ranged from 0.45 to 2.15 mgd and averaged 1.36 mgd.

TABLE II-14

ANALYSIS OF GRAB SAMPLES FROM MONTH-LONG STUDY, WINTER 1969-70

Station	Flowrate, mgd			Temperature °F			pH			BOD mg/1			Chemical Oxygen Demand mg/1		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	0.31	1.26	0	94	110	72	6.6	7.1	6.0	1,680	3,472	168	1,708	3,800	66
S-2	0.63	1.80	0.08	92	112	70	6.7	8.5	5.8	664	4,368	56	878	4,488	80
S-3	--	--	--	84	100	33	6.4	6.8	6.1	1,366	2,800	135	1,426	3,100	471
S-4A	--	--	--	88	100	80	6.4	7.3	5.6	963	2,520	280	1,107	1,965	502
S-4B	--	--	--	89	94	82	6.6	7.3	6.3	1,028	10,008	392	937	1,219	600
S-5	0.84^1	2.21^1	0.11^1	85	96	82	6.6	8.7	5.7	926	2,128	168	990	2,226	233
S-6	0.13	0.29	0.04	72	78	64	8.5	9.3	7.1	19	174	0	58	460	0
S-7	0.03	0.10	0	59	65	51	8.2	8.9	6.4	650	2,352	0	10,762	72,000	200
S-8^2	0.85	1.70	0.02	76	90	64	7.0	8.3	6.5	693	1,288	56	731	1,421	136
S-9	2.58	4.05	0.77	81	86	74	7.0	8.9	6.2	825	4,480	112	1,021	2,686	224
S-10	2.37	5.12	0.80	78	83	68	7.0	7.4	6.4	441	748	112	683	1,382	224
S-11^3	--	--	--	--	--	--	6.9	7.3	6.6	240	340	160	436	560	343
S-13^3	--	--	--	--	--	--	6.5	7.0	6.1	161	228	60	274	365	164
S-14^3	--	--	--	--	--	--	7.2	7.4	7.0	73	108	36	216	334	167
S-15^3	--	--	--	--	--	--	6.7	7.2	6.7	52	82	24	187	251	119

TABLE II-14 (Continued)

ANALYSIS OF GRAB SAMPLES FROM MONTH-LONG STUDY, WINTER 1969-70

Station	Grease, mg/1			Specific Electrical Conductance, micromhos/cm			Total Solids mg/1			Suspended Solids mg/1			Settleable Solids mg/1			Sulfide mg/1		
	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
S-1	140	579	2	1,449	4,500	334	2,171	4,500	190	868	2,416	88	9	30	TR	--	--	--
S-2	813	2,051	1	2,763	10,300	770	2,221	7,864	296	682	5,804	52	12	100	TR	--	--	--
S-3	100	374	18	1,463	2,060	642	1,896	2,648	664	463	856	252	3	10	TR	--	--	--
S-4A	234	463	56	2,207	4,500	1,160	2,042	3,920	1,040	515	1,116	164	6	40	TR	--	--	--
S-4B	306	757	9	2,010	3,210	1,280	2,129	4,096	1,496	653	3,088	256	8	54	TR	--	--	--
S-5	173	583	2	2,304	6,450	1,030	2,207	4,552	744	446	1,948	68	6	30	TR	--	--	--
S-6	1	2	0	400	745	280	220	740	80	63	136	20	TR	TR	TR	--	--	--
S-7	74	148	29	2,499	7,220	450	3,085	8,168	80	1,434	4,940	48	22	65	TR	--	--	--
S-8	156	444	1	1,869	3,220	1,090	1,709	2,840	532	529	1,252	60	5	15	1	2.0	5.0	TR
S-9	557	3,245	17	1,566	2,820	900	2,438	7,976	804	591	1,384	156	5	11	TR	2.0	4.2	TR
S-10	69	204	11	1,201	1,800	805	1,367	2,536	544	452	1,360	168	5	11	0	1.9	4.1	0
S-11	--	--	--	848	1,150	23	937	1,224	712	204	307	154	7	20	4	0.2	0.5	0
S-13	--	--	--	827	1,090	30	797	962	580	56	173	24	TR	10	TR	--	--	--
S-14	--	--	--	820	1,090	21	756	932	510	98	165	49	1	7	TR	--	--	--
S-15	--	--	--	807	1,090	15	715	926	388	37	90	17	TR	1	TR	--	--	--

[1] Flowrate is sum of treated effluent (S-5) and the boiler and engine building effluent (S-6).

[2] Excludes 20-minute long peak discharges 3 times a week when the flotation tanks were emptied.

[3] Values are from daily composited samples.

TABLE II-15

ANALYSIS OF COMPOSITE SAMPLES FROM MONTH-LONG STUDY, WINTER 1969-70

Station	pH	Total Hardness ($CaCO_3$) mg/1	Total Alkalinity ($CaCO_3$) mg/1	Grease mg/1	Specific Electrical Conductance micromhos/cm	Total Solids mg/1	Fixed Solids mg/1	Volatile Solids mg/1	Suspended Solids mg/1	Settleable Solids mg/1	Dissolved Solids mg/1
S-1	6.6	120	680	900	900	2,168	588	1,580	978	12	1,190
S-2	6.8	40	660	1,661	2,050	4,660	1,424	3,236	1,922	40	2,738
S-3	7.1	32	400	621	1,160	2,153	877	1,276	580	6	1,573
S-4A	7.1	32	312	334	1,670	2,478	1,277	1,201	680	9	1,798
S-4B	7.3	44	395	198	1,540	2,056	1,021	1,035	402	6	1,654
S-5	7.3	32	205	167	1,540	1,790	866	924	410	8	1,380
S-6	8.1	28	132	3	273	266	135	131	32	TR	234
S-7	7.9	172	588	7	2,310	3,064	1,084	1,980	1,384	35	1,680
S-8	7.1	80	298	185	1,280	1,796	917	879	556	10	1,240
S-9	6.7	112	200	363	1,410	2,204	1,202	1,002	534	7	1,670
S-10	6.7	112	232	230	1,030	1,304	714	590	422	6	882
S-11	7.1	152	176	152	835	972	575	397	194	7	778
S-13	7.0	136	240	67	800	780	506	274	50	TR	730
S-14	7.3	148	180	41	800	708	461	247	86	1	622
S-15	7.3	140	164	32	800	704	500	204	38	TR	666

TABLE II-15 (Continued)

ANALYSIS OF COMPOSITE SAMPLES FROM MONTH-LONG STUDY, SUMMER 1970, in mg/l

Station	Ammonia (NH_3)	Organic Nitrogen (N)	Total Kjeldahl Nitrogen (N)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Total Phosphate (PO_4)	Iron (Fe)
S-1	42	36	78	42	4	172	38	58	150	64	0.40
S-2	87	64	151	16	TR	520	35	16	710	33	0.08
S-3	48	25	73	13	TR	248	42	14	355	55	0.32
S-4A	28	28	56	13	TR	460	25	14	645	22	0.20
S-4B	34	25	59	18	TR	350	28	14	535	24	0.20
S-5	50	22	73	13	TR	100	3	12	580	28	0.04
S-6	0	0	0	11	TR	66	1	4	60	6	0.28
S-7	196	50	246	56	8	80	166	30	200	97	0.80
S-8	56	31	87	22	6	250	35	18	390	30	0.12
S-9	48	25	73	29	10	360	28	26	565	24	0.04
S-10	34	--	18	34	7	190	18	22	485	25	0.40
S-11	21	13	34	48	8	140	12	16	250	17	0.25
S-13	19	6	24	43	7	164	12	16	245	19	0.04
S-14	20	6	25	51	5	156	11	16	235	19	0.04
S-15	17	5	22	50	4	156	12	16	240	17	0.04

TABLE II-16

AVERAGE WASTEWATER CHARACTERISTICS FROM GRAB SAMPLES
SWIFT AND COMPANY EFFLUENT

Characteristic	24-Hour Study				Month-Long Study			
	Sampling Program			Average	Sampling Program			Average
	Spring	Summer	Winter[2]		Spring	Summer	Winter	
Flowrate, mgd[1]	0.84	1.10	0.95[1]	0.96	1.08	1.05	0.85	1.07
Temperature, °F	--	87	--	87	87	88	76	84
pH	6.9	7.2	6.7	6.9	7.7	7.3	7.0	7.3
BOD, mg/l	1,308	787	1,063	990	773	696	693	721
COD, mg/l	528	699	1,592	940	595	415	731	580
Grease, mg/l	256	244	--	250	103	127	156	129
Specific Electrical Conductance, micromhos/cm	1,490	1,396	1,506	1,464	1,297	1,462	1,869	1,543
Total Solids, mg/l	1,748	1,839	3,196	2,261	1,520	1,673	1,709	1,634
Suspended Solids, mg/l	565	508	975	683	380	380	529	430
Settleable Solids, mg/l	3	4	39	15	8	1	5	5
Ammonia (NH_3), mg/l	39	22	44	35	--	--	--	--
Total Kjeldahl Nitrogen (N), mg/l	61	37	68	55	--	--	--	--
Organic Nitrogen (N), mg/l	22	15	24	20	--	--	--	--
Total Phosphate (PO_4), mg/l	23	16	40	26	--	--	--	--
Sulfide (S), mg/l	--	--	--	--	--	--	2	2

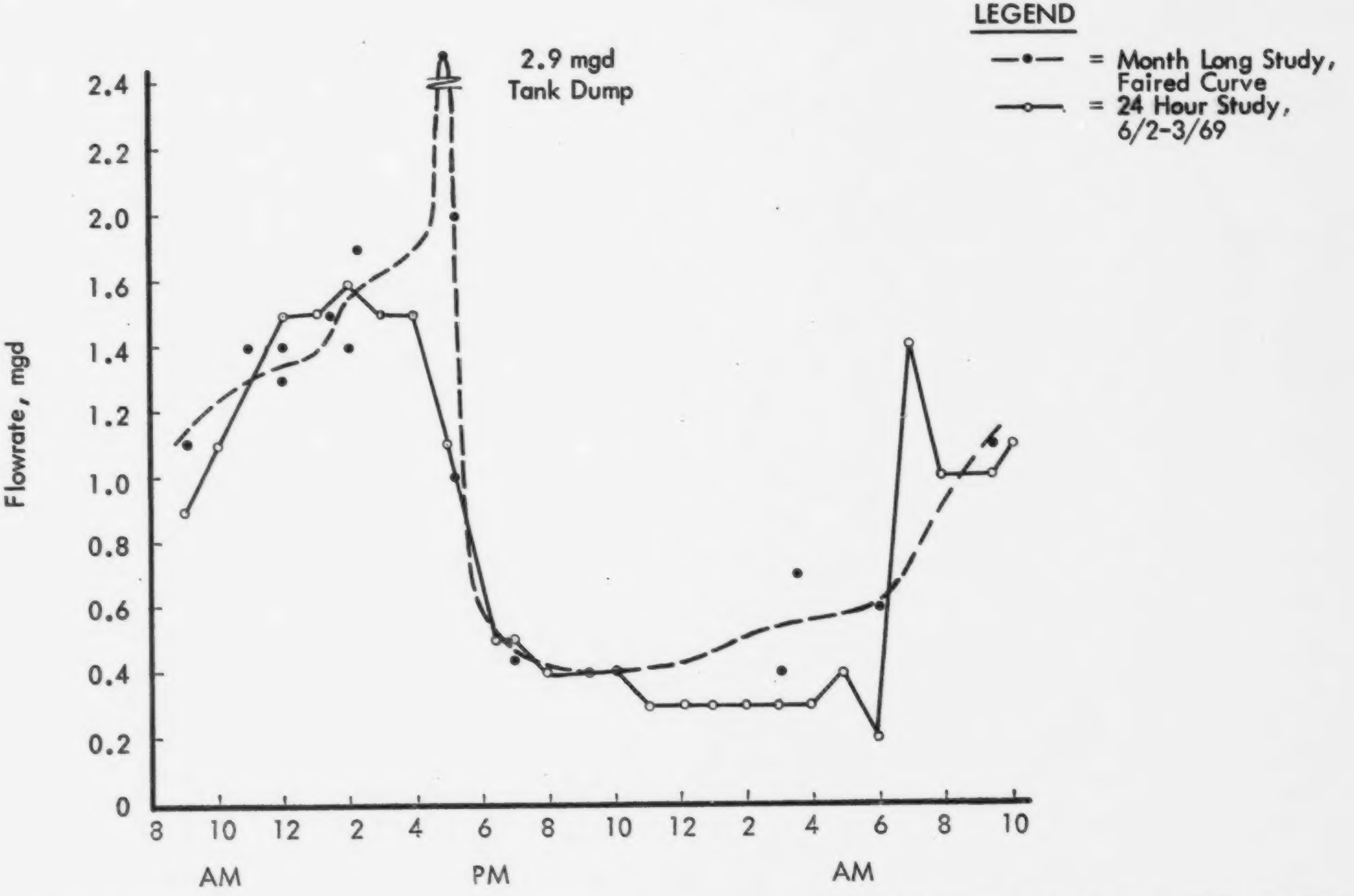
[1] Recorded flowrate. Measured flowrate was 30 to 50 percent higher.

[2] From the 22 samples collected on January 15-16, 1970.

TABLE II-17

AVERAGE WASTEWATER CHARACTERISTICS FROM COMPOSITED SAMPLES SWIFT AND COMPANY EFFLUENT

Characteristic		Sampling Program			Average
		Spring	Summer	Winter	
pH		7.0	6.9	7.1	7.0
Total Hardness ($CaCO_3$), mg/l		20	50	80	50
Total Alkalinity ($CaCO_3$), mg/l		280	400	298	326
Grease, mg/l		133	114	185	144
Specific Electircal Conductance, micromhos/cm		1,155	1,350	1,280	1,262
Solids, mg/l:	Total	1,495	1,569	1,796	1,620
	Fixed	395	1,001	917	771
	Volatile	1,100	568	879	849
	Suspended	494	504	556	518
	Settleable	5	5	10	7
	Dissolved	1,001	1,065	1,240	1,102
Ammonia (NH_3), mg/l		27	34	56	39
Organic Nitrogen (N), mg/l		7	14	3	17
Total Kjeldahl Nitrogen (N), mg/l		34	48	87	56
Calcium (Ca), mg/l		8	20	22	17
Magnesium (Mg), mg/l		TR	TR	6	2
Sodium (Na), mg/l		195	330	250	258
Potassium (K), mg/l		20	15	35	23
Sulfate (SO_4), mg/l		20	25	18	21
Chloride (Cl), mg/l		265	460	390	372
Total Phosphate (PO_4), mg/l		22	12	30	21
Iron (Fe), mg/l		0.12	0.24	0.12	0.16



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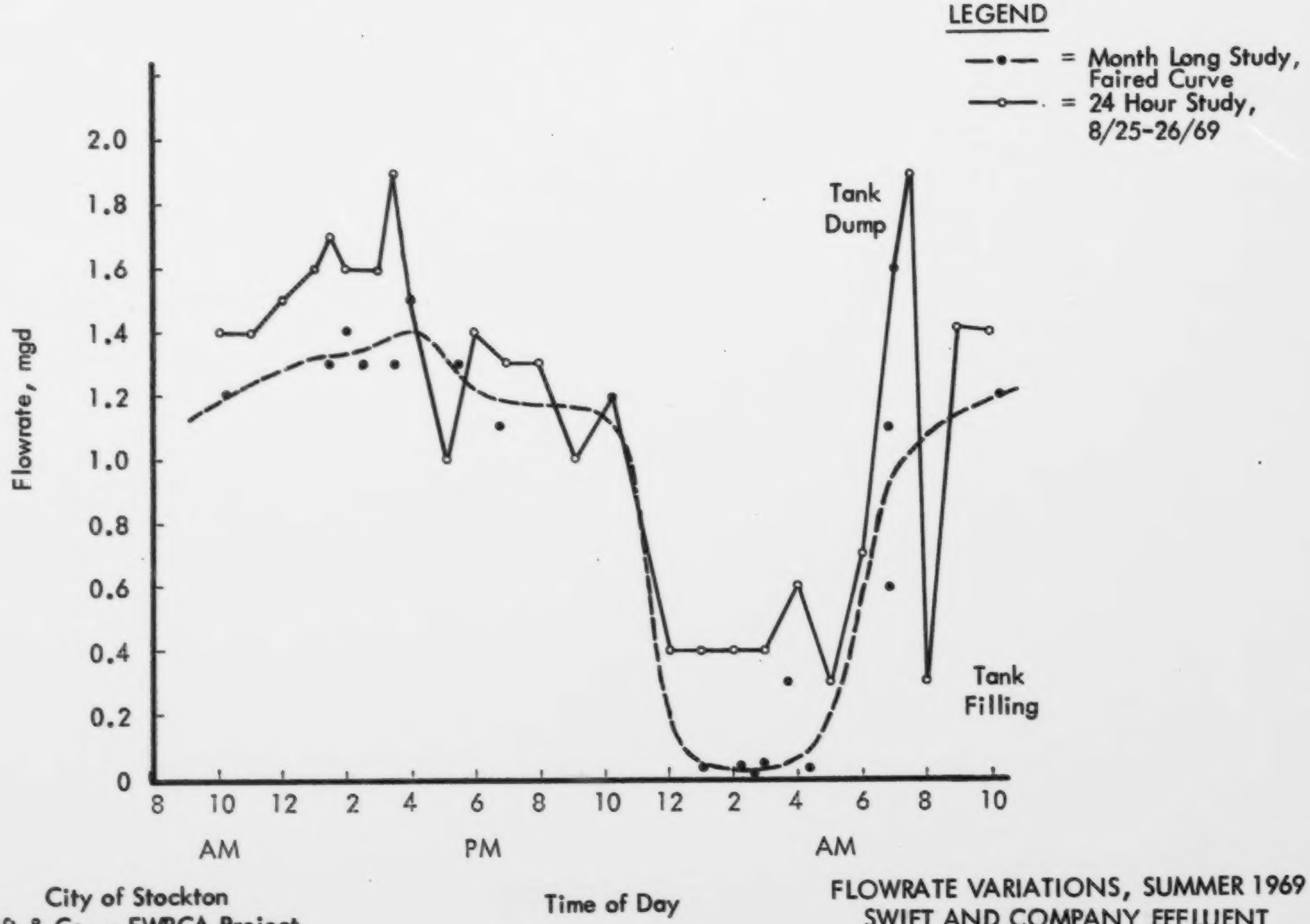
FLOWRATE VARIATIONS, SPRING 1969
SWIFT AND COMPANY EFFLUENT

FIGURE II-5



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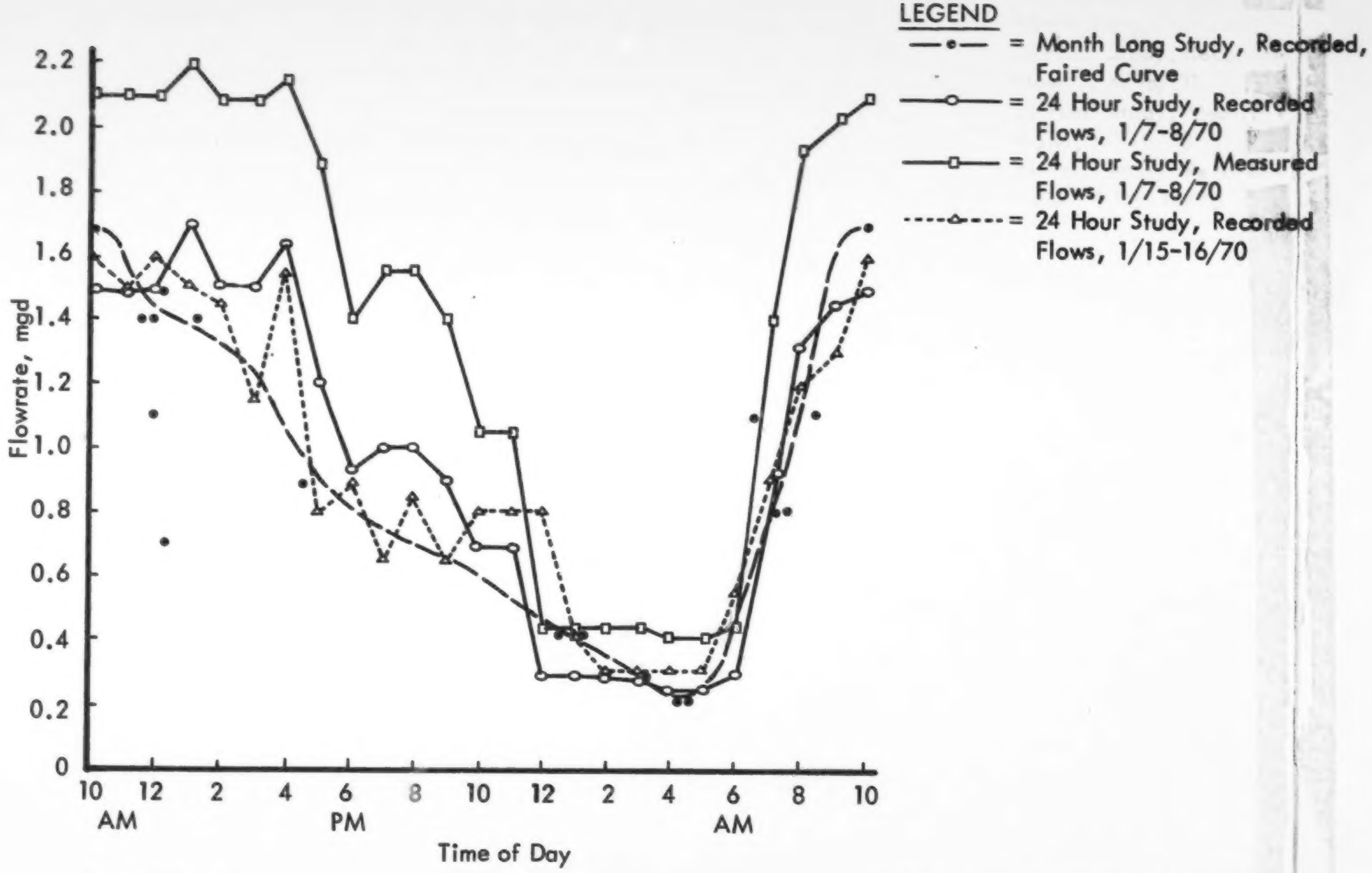
FLOWRATE VARIATIONS, SUMMER 1969
SWIFT AND COMPANY EFFLUENT

FIGURE II-6



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FLOWRATE VARIATIONS, WINTER 19 -7
SWIFT AND COMPANY EFFLUE
FIGURE II-7

1969, when 900 cattle were processed daily, the flow was more than 1.0 mgd until 11:00 P.M. Three peak discharges per week occurred when the flotation tanks were emptied (these peaks were not plotted on the month-long flowrate curves). The peak flows ranged from 1.5 mgd to 2.9 mgd and lasted from 20 to 30 minutes. Analyses of typical dumps of the plant waste and paunch separator are summarized in Table II-18. Except for the higher suspended solids concentrations, the characteristics of these discharges are generally similar to those measured during normal operations.

As shown on Figure II-8 to II-10, the variations in BOD concentration in plant effluent are generally proportional to the flow variation; i.e., the BOD was in the order of 1000 to 1200 mg/l during the day, from 8:00 A.M. to 6:00 P.M. when the 1.0 to 1.9 mgd flow range occurred, and dropped to a 100 to 900 mg/l range during plant clean-up and thereafter, until beef processing again resumed at 6:00 A.M. during the work week.

The average values calculated from the grab samples collected over the month-long period were probably more representative of typical plant conditions than those for the 24-hour period. A case in point is the Spring Sampling Period. The 24-hour average BOD (arithmetic average) of 1308 mg/l was nearly twice the month-long average of 773 mg/l. This increase was partially caused by a large amount of blood waste discharged into the sewer because of a blood drain being temporarily plugged. In the Fall Sampling Period, the plant effluent 24-hour and month-long average BOD (arithmetic average) were 787 mg/l and 696 mg/l, respectively.

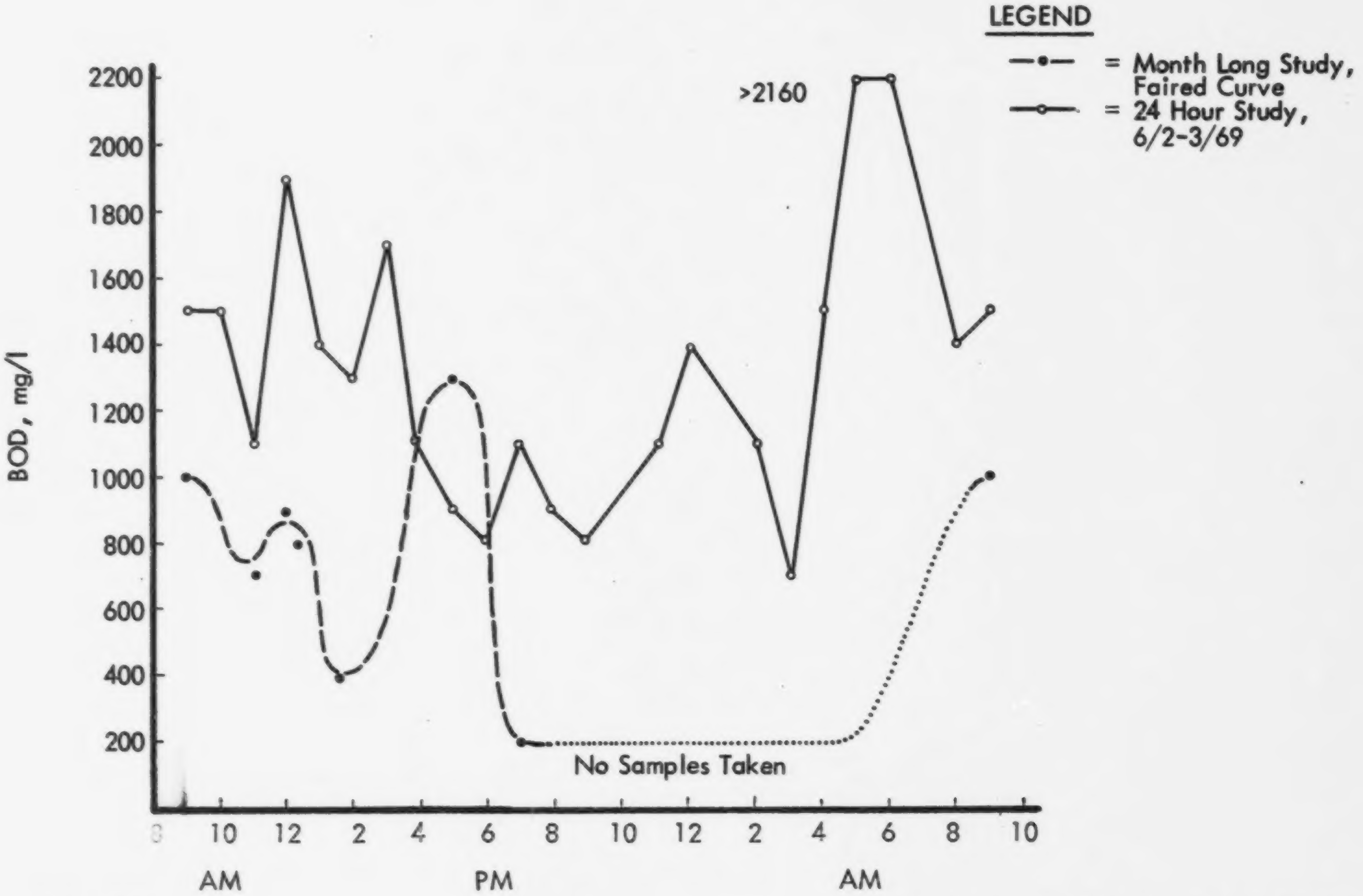
During the Winter Sampling Period, a 24-hour sampler was used to automatically collect a sample every hour. This sampling device was used on January 7-8 and on January 15-16, 1970. During the sampling of January 7-8, only one sample was collected between 12:00 Noon and 9:00 P.M. due to plugging of the suction line. Since the BOD was normally highest during these hours, the average computed BOD of 689 mg/l was low. This low figure may be attributed to the fact that the laboratory tests for these samples were not performed until January 10, 1970. During the sampling of January 15-16, 22 samples were collected out of a possible 24. The average BOD was 1063 mg/l. The average BOD determined from the month-long study was 693 mg/l.

Average BOD's weighted for recorded flows, and corrected for measured flows, are summarized in Table II-19. They ranged from a month-long BOD weighted average minimum of 693 in the winter to 960 minimum for the summer. The weighted 24-hour BOD samplings ranged from a minimum 790 for the summer to 1340 maximum for the spring.

TABLE II-18

ANALYSIS OF AIR FLOTATION TANK DUMPS

Characteristic	Paunch Separator, 1/31/70			Plant Waste Separator, 1/9/70		
	2:15 AM	2:30 AM	2:45 AM	10:15 AM	10:25 AM	10:35 AM
Temperature, ^oF	89	89	89	90	90	88
pH	6.2	6.3	6.4	6.3	6.5	6.4
BOD, mg/1	1,568	1,120	1,904	560	336	560
COD, mg/1	2,024	2,042	2,508	735	590	1,350
Grease, mg/1	185	417	456			
Specific Electrical Conductance, micromhos/cm	1,540	1,540	1,540	1,540	1,540	1,540
Total Solids, mg/1	1,776	1,684	1,952	1,720	1,920	2,792
Suspended Solids, mg/1	400	1,884	1,832	572	576	1,192
Settleable Solids, mg/1	TR	TR	10	4	TR	20



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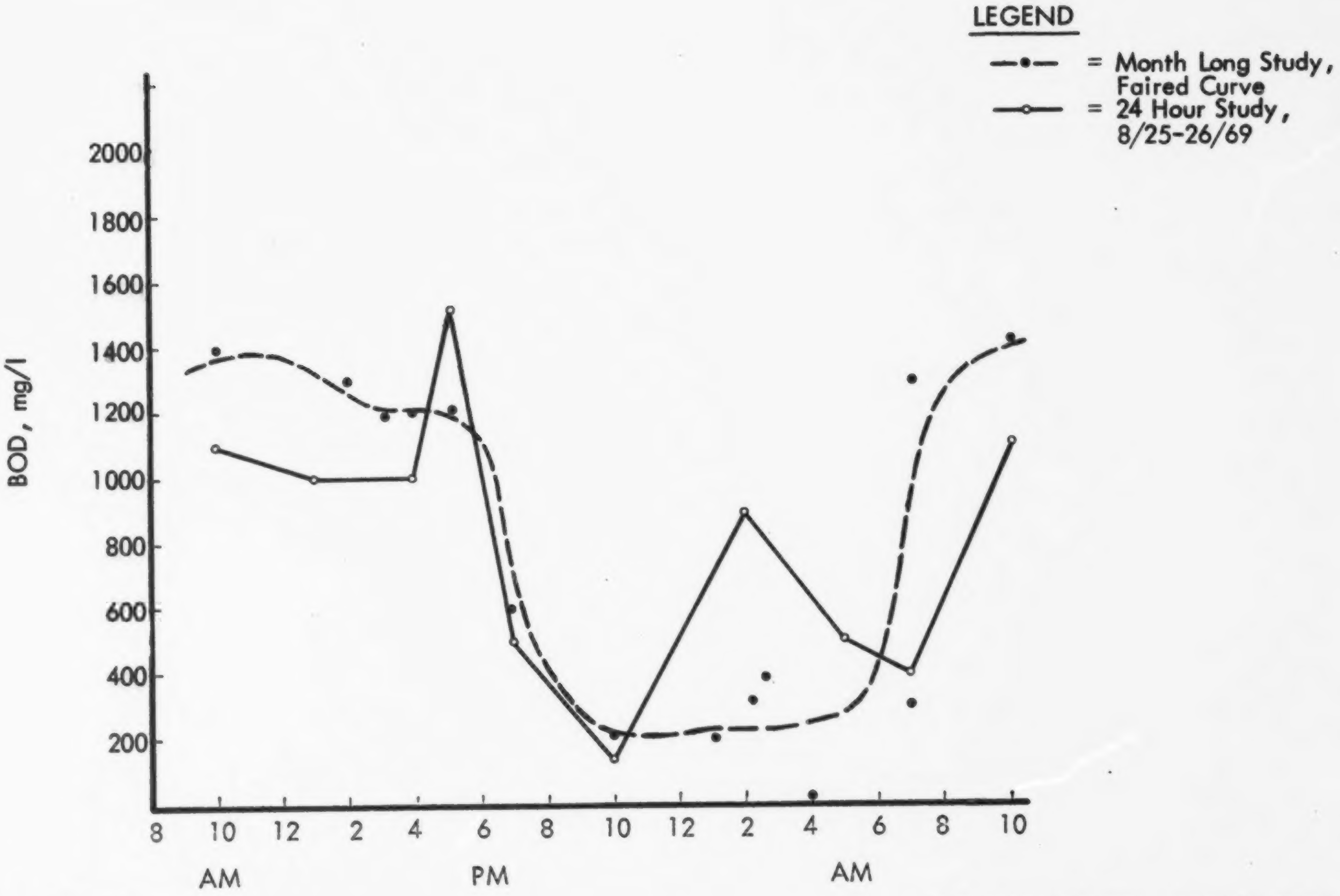
BOD VARIATIONS, SPRING 1969
SWIFT AND COMPANY EFFLUENT

FIGURE II-8



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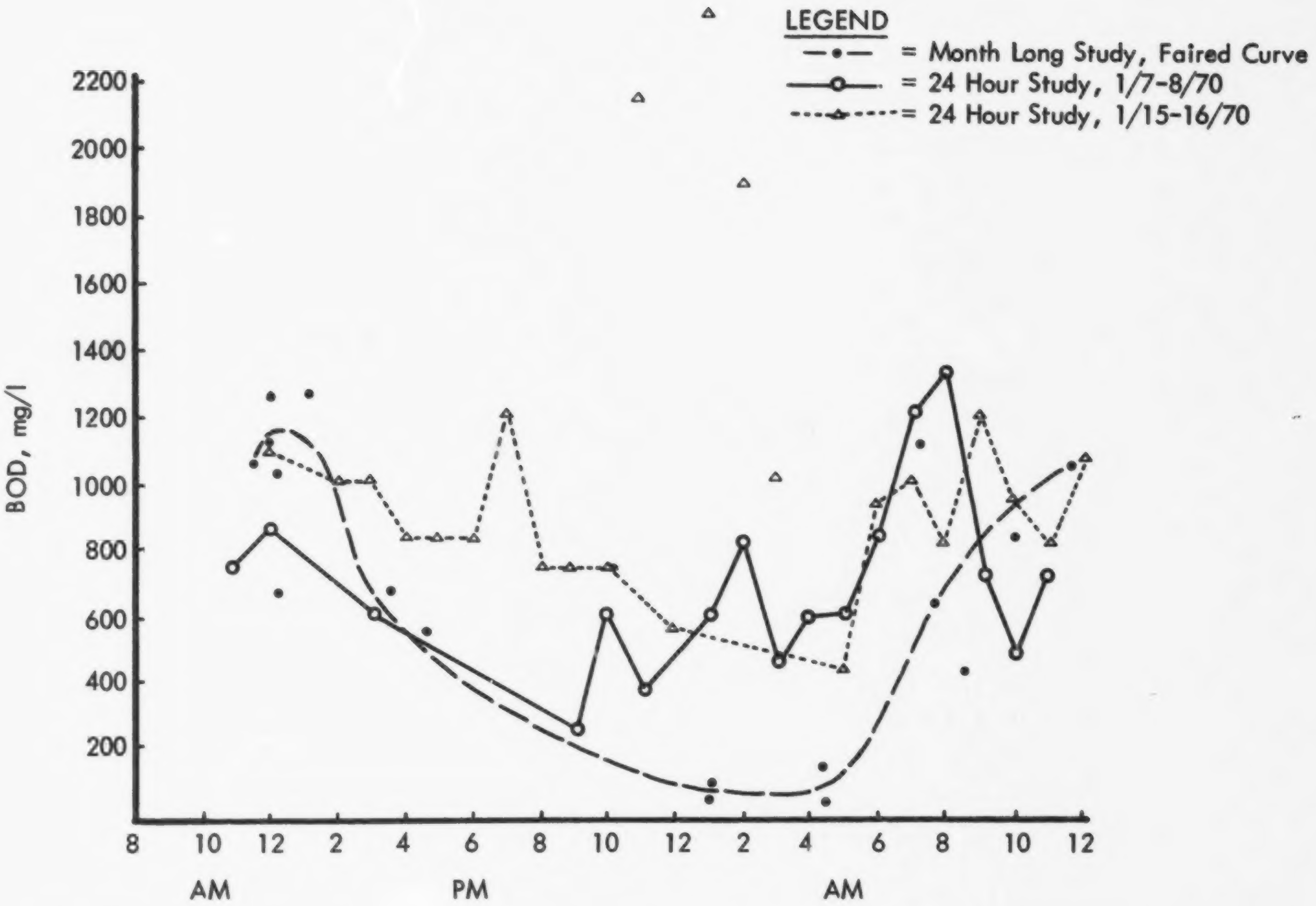
BOD VARIATIONS, SUMMER 1969
SWIFT AND COMPANY EFFLUENT

FIGURE II-9



City of Stockton
Swift & Co. - FWPCA Project

BOD VARIATIONS, WINTER 1969-70
SWIFT AND COMPANY EFFLUENT
FIGURE II-10

TABLE II-19

SWIFT AND COMPANY WASTELOAD (BOD)

Sampling Period	Weighted Concentration mg/l	Wasteload, lb/day	
		Recorded[1] Flows	Measured[2] Flows
24-hour, Spring	1,340	9,340	--
Month-long, Spring	670	4,390	--
24-hour, Summer	790	6,860	--
Month-long, Summer	960	7,420	--
24-hour, Winter			
1/7-8/70	689	5,140	7,720
1/15-16/70	1,063	7,760	11,450
Month-long, Winter	693	6,080	8,880

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[1] Based on flows recorded on 7-day chart at Parshall flume.

[2] Computed based on measured depth of flow and calibration curve for the Parshall flume.

III. SOUTHERN INDUSTRIAL SANITARY TRUNK SEWER

A. DESCRIPTION

The Southern Industrial Trunk is some eight miles in length. It consists of 10,509 ft of 48 in. reinforced concrete pipe (RCP); 17,925 ft of 42 in. RCP; and 11,917 ft of 30 in. RCP. As shown on Figures II-1 and II-2 it extends from Mariposa Road, east of Highway 99, to the Main Water Quality Plant. The sewer was constructed in 1959 and 1960, except for 1,313 ft length of 42 in. RCP that existed prior to 1959. It cost approximately $1,046,000 to construct and its replacement cost (1970) was estimated at $1,630,000. In 1968 a 700-ft-long 24 in. vitrified clay pipe (VCP) was constructed to connect the Swift plant to the Southern Industrial Trunk. The 30 in. section of trunk sewer from Mariposa Road to Airport Way was for all practical purposes dry for the first ten years. In 1969, when Swift started operation, discharges to the trunk sewer were approximately 1.5 mgd. In 1969 sewers were constructed in the residential area on Ralph Avenue. About 0.1 mgd has been discharged by this area directly to the Southern Industrial Trunk. For several years the trunk sewer from Airport Way has contributed sewer flows ranging up to 1.0 mgd. Since 1965 the Southern Industrial Trunk has been accepting wastewater from the California Youth Authority (CYA); these discharges have reportedly averaged 0.5 mgd. For the past four to five years discharges during the canning season have been made by the Valley Tomato Products Co. and the H. J. Heinz Company. At the height of the canning season these discharges have averaged about 1.0 and 2.5 mgd, respectively, for the aforementioned tomato processing plants.

Over the last ten years small quantities of wastewater have been discharged into various downstream sections of the trunk sewer.

For the purpose of evaluating different methods of protecting the Southern Industrial Trunk against corrosion, flows were measured in the field at various times during 1969. Additionally, flows were computed based on residential population (80 gpcpd) and waste discharges from dry industries (0.01 mgd/acre). Table III-1 is a compilation of the dry weather flows during the canning and non-canning seasons. Figure III-1 shows the tributary sub-acres. These flowrates do not represent precise figures, but are engineering estimates used as the basis for developing design criteria and costs.

B. SEWER RECONNAISSANCE

During the one year study, the Southern Industrial Trunk was field surveyed several times to determine: physical deterioration, odor, sedimentation, corrosion, and other factors. In general, the overall sewer appeared to be in satisfactory condition. This was particularly true for the upstream 30 in. diameter section which was placed in use in January 1969. Local complaints concerning odors emanating from certain areas of the sewer were confirmed by these field studies. Odors were observed

TABLE III-1

AVERAGE FLOWRATES FROM TRIBUTARY SUBAREAS AND IN SOUTHERN INDUSTRIAL SANITARY TRUNK SEWER, mgd

Subarea Designation	Subarea Description	Canning Season 1969	Non-Canning Season, 1969	Peak Measured Flow	Design Capacity[1]
A	Swift and Company, measured	1.5	1.5		
A1	Industrial area fronting on Loomis Road, estimated	0.1	0.1		
B	Residential Area				
	Directly to trunk sewer; 1,100 persons @ 80 gpcpd	0.1	0.1		
	Airport Way Sewer; 5,200 persons @ 80 gpcpd	0.4 [2]	0.4 [3]		
	Airport Way Sewer; Light industrial and commercial	0.3	0.1		
	Projected future growth, 2,200 persons[4]	--	--		
Subtotals					
	Computed	2.4	2.2		
	Measured	2.8	2.5	6.3	12.0
C	Industrial Area				
	70 acres occupied[4]	0.7	0.7		
	690 acres undeveloped	--	--		
	H. J. Heinz Co., measured[5]	2.5	0		
D	Industrial Area				
	Airport Way Development Area, estimated	0.1	0.1		
	Valley Tomato Products, measured[5]	1.2			
	C.Y.A., estimated	0.5[6]	0.2[7]		
Subtotals					
	Computed	7.4	3.2		
	Measured	7.2	2.4	9.9[8]	12.0

TABLE III-1 (Continued)

AVERAGE FLOWRATES FROM TRIBUTARY SUBAREAS AND IN SOUTHERN INDUSTRIAL SANITARY TRUNK SEWER, mgd

Subarea Designation	Subarea Description	Canning Season 1969	Non-Canning Season, 1969	Peak Measured Flow	Design Capacity[1]
E	Residential Area				
	Existing, estimated 5,000 population @ 80 gpcpd	0.4	0.4		
	Ultimate 18,000 population on 1,380 acres @ 80 gpcpd	--	--		
Totals, computed		7.8	3.6	10.3	16.0

[1] Without surcharge.

[2] Estimated based on visual examination.

[3] Measured 0.45 mgd flow in Airport Way sewer on December 11, 1969.

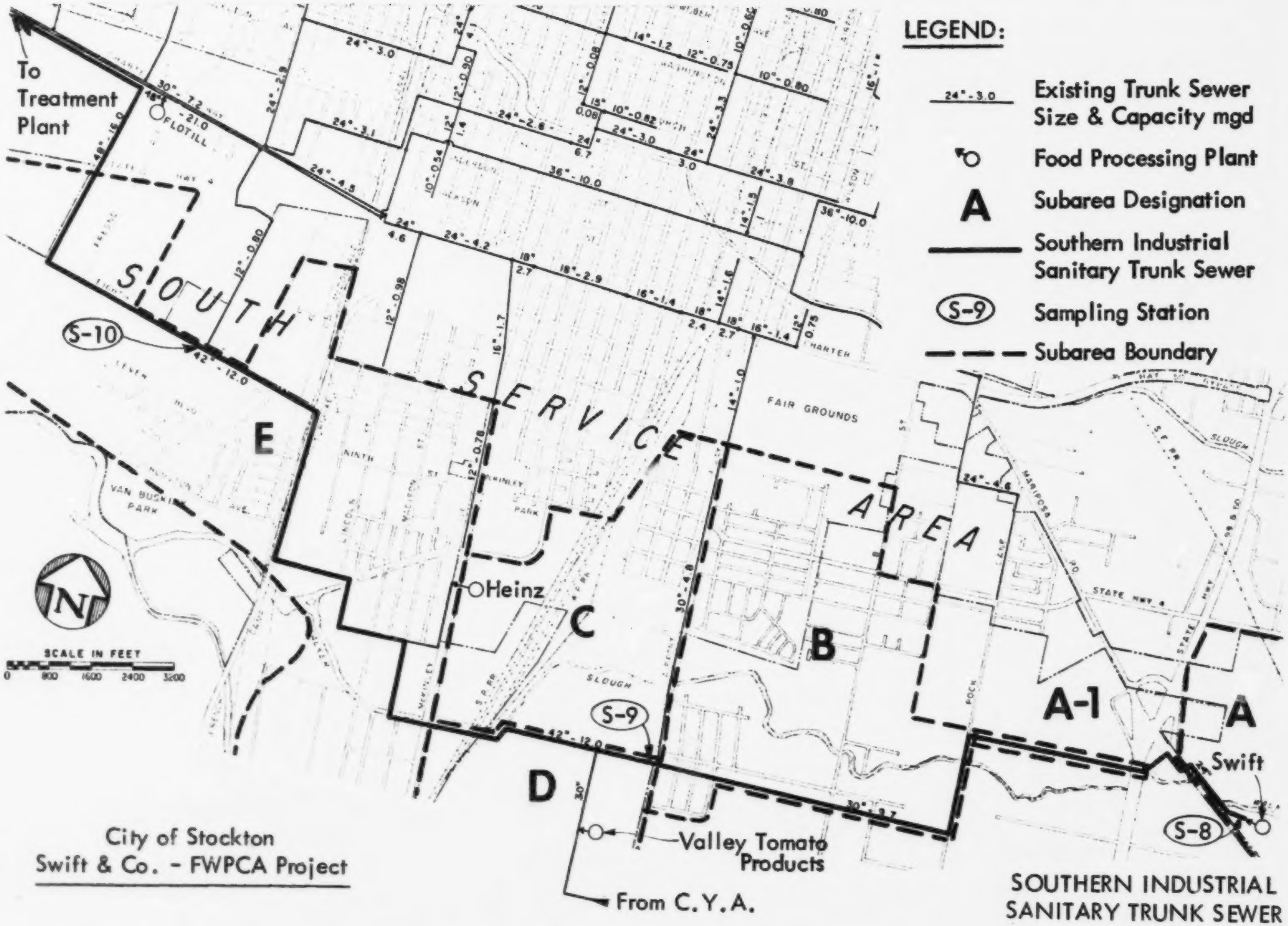
[4] From Table 2 of Brown and Caldwell, Consulting Engineers report entitled "City of Stockton Sewerage Improvements for Proposed Industrial Expansion", December 1966.

[5] Average flow measured by City personnel during height of canning season, for computation of sewer service charges.

[6] Estimated by City.

[7] Measured at 4:30 P.M. on December 11, 1969.

[8] Measured flow at Sampling Station (S-10) less 0.4 mgd from Subarea E.


LEGEND:
24"-3.0 Existing Trunk Sewer Size & Capacity mgd
Food Processing Plant
A Subarea Designation
Southern Industrial Sanitary Trunk Sewer
S-9 Sampling Station
Subarea Boundary
To Treatment Plant
FLOTILL
SOUTH SERVICE AREA
S-10
42"-12.0
E
VAN BUSKIRK PARK
Heinz
C
B
A-1
A
Swift
S-8
S-9
D
Valley Tomato Products
From C.Y.A.
FAIR GROUNDS
SLOUGH
STATE HWY 4
MARIPOSA RD.
30"-7.2
48"-21.0
36"-10.0
24"-3.0
24"-4.5
24"-4.2
24"-4.6
24"-2.6
24"-3.1
30"-4.8
30"-3.7
16"-1.7
12"-0.78
12"-0.98
12"-0.80
SCALE IN FEET
0
800
1600
2400
3200
N

City of Stockton
Swift & Co. - FWPCA Project

SOUTHERN INDUSTRIAL
SANITARY TRUNK SEWER
FIGURE III-1

primarily at locations where there was turbulent flow due to pipe junctions and bends. Where the flow was laminal and relatively smooth, minimum odors were observed outside of the manhole covers. Odors at present (1970) do not present a severe environmental nuisance because the land along the course of the sewer is relatively undeveloped. The older sections of sewer showed corrosion effects and demonstrated the importance of providing corrosion protection.

In addition to the aforementioned routine evaluations of sewer conditions, a more thorough investigation was conducted on December 11, 1969. This investigation included climbing into and sampling manholes along the Southern Industrial Trunk and main tributary sewers. The physical results of this sewer reconnaissance are summarized in Table III-2. In the upstream reaches of the sewer, closer to the Swift plant, the odors were moderately strong and were characteristic of meat packing waste odor. Large quantities of steam were present; extensive condensation on the walls of the manholes promoted the growth of slime above the flow line.

At distances far from Swift where other flows entered the trunk sewer, the steam level was reduced significantly. Sewer odors were more septic and stronger. The odors were especially apparent in the upper 2 ft of the manholes. Odor intensity diminished dramatically as the manhole widened out to a 4 ft diameter below the 2 ft diameter top section. At no time were the odors so overpowering that it was necessary to air out the manhole before entering it.

C. SEWAGE SAMPLING PROGRAM

Sampling programs were designed to determine the waste characteristics and flow volumes in the trunk sewer. The sampling stations in the Southern Industrial Trunk were designated S-9 and S-10. Figures II-1 and III-1 show the location of these stations. Station S-9 was immediately downstream of the intersection of Airport Way and Ralph Avenue; Station S-10 was on Eighth Street at the intersection of Argonaut Street. Generally the schedule for sampling in the trunk sewer was 1 to 4 hours after the Swift samples were taken. This corresponded to the time for the wastewater at Swift to flow to the sampling points.

Samples were collected, stored, and analyzed. The flows were measured in the same general manner as described in Chapter II-B-2 for the Swift sampling, except that City personnel performed the sampling and that a 24-hour day sampling period was not provided. Appendix D presents the form used to record data during the sampling tests.

The results of the sampling, analyses, and flow measurements are in Tables II-8 to II-15. The effects of Swift discharges on the trunk sewer were determined by comparing the characteristics for Stations S-9 and S-10 with those at Swift (S-1 to S-8).

TABLE III-2

TRUNK SEWER RECONNAISSANCE SUMMARY[1]

Sewer Location	Flow Description	Condensation on Walls	Slime and Deposition	Corrosion	Odors		Remarks
					Intensity	Classification	
Manhole 47 per Figure V-10 west of Hwy 99 Freeway	Smooth	Heavy; promoted slime growths 1/16" to 1/8" thick on manhole walls	1/8" thick on sides of flow channel below water level; none on bottom of channel	None	Moderate	Not noxious; Blood odor	4" inlet discharged sanitary sewage from adjacent "dry" industrial plant. Second 4" inlet was dry--may have been used for a vent.
Manhole 50 ft downstream of Manhole 47	Smooth	None; apparently all steam and vapor exhausted from Manhole 47	Did not crawl into manhole to observe slime below water level	Did not crawl into manhole; none observed from surface	Moderate	Blood odor	
Manhole 40 per Figure V-10at intersection of Pock Lane and Ralph Avenue projected	Turbulent	Heavy; promoted slime growths 1/16" to 1/8" thick on manhole walls	0 to 1/2" thick below water level; none where flow was turbulent; 1/2" where flow was quiescent	None	Moderate	Blood odor	90° bend in trunk sewer.

TABLE III-2 (Continued)

TRUNK SEWER RECONNAISSANCE SUMMARY[1]

Sewer Location	Flow Description	Condensation on Walls	Slime and Deposition	Corrosion	Odors		Remarks
					Intensity	Classification	
Manhole 31 per Figure V-10 at intersection of Airport Way and Ralph Avenue	Highly turbulent	Moderate, promoted slime growths up to 1/16" thick on manhole walls	No slime where flow was turbulent. Slimes and sand deposits up to 1" thick where flow was quiescent	Rust on manhole cover. Severe corrosion of grout: ranged up to 2" deep immediately above water level and 1 1/2" deep below water line	Strong	Septic	30" diameter influents to manhole from east along Ralph Avenue and from north along Airport Way. 42" diameter effluent at 30° angle to the southwest.
30" diameter Airport Way trunk, first two manholes north of Ralph Avenue	Smooth	None	None on walls. Did not crawl into manholes to observe slimes below water level	Rust on manhole cover. Did not crawl into manholes to observe corrosion below water level	Moderate	Septic	
30" C.Y.A. trunk sewer, south of Southern Industrial Trunk	Smooth	None	Same as immediately above	Same as immediately above except no rust on manhole cover	Minor	Barnyard	Valley Tomato Products plant was not operating.

TABLE III-2 (Continued)

TRUNK SEWER RECONNAISSANCE SUMMARY[1]

Sewer Location	Flow Description	Condensation on Walls	Slime and Deposition	Corrosion	Odors		Remarks
					Intensity	Classification	
Eighth Street at Lever Blvd	Semi-Smooth	Heavy; promoted slime growths up to 1/4" thick on manhole walls	Did not crawl into manhole to observe slimes below water level	Rust on manhole cover. Did not crawl into manhole to observe corrosion below water level	Strong	Septic/ Blood	12" main sewer from Lever Blvd. discharges to the manhole from the south
Eighth Street at Argonaut Avenue	Smooth	Heavy in some sections[1] of the manhole and slight in other sections; slime growths on walls up to 1/4" thick	1/8" thick below water level except on channel shelf where growths and sand deposits were up to 2" thick	Heavy rust on manhole cover. Minor at and below water level	Strong	Septic/ Blood	

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[1] Reconnaissance done on December 11, 1969.

At Station S-9, the average flowrate ranged from 2.2 to 2.8 mgd for the three sampling periods. Sixty to 70 percent of the flow was from Swift. The remainder of the sewage was attributed to light industrial, commercial, and residential sources, most of which was discharged from the Airport Way sewer into the Southern Industrial Trunk. This flow was not affected significantly by seasonal factors.

The flow at Station S-10 averaged 2.4 and 7.2 mgd during the non-canning and canning seasons, respectively. Most of this increased flow was from discharges by the H. J. Heinz and Valley Tomato Products canneries, which was about 4 mgd during the height of the canning season.

As illustrated on Figures III-2 and III-3, sewage flows at Stations S-9 and S-10 varied dramatically throughout the 24-hour day. In addition to the hourly variations, Figure III-3 illustrates the significant effect of the cannery waste discharges. Flowrates ranged from about 5 mgd at 7:00 A.M. to 9.5 mgd at 2:00 P.M. during the canning season, compared to ranges of 1.2 mgd at 7:00 A.M. to 2.8 mgd from 12:00 noon to 8:00 P.M. during the non-canning season. The minimum flows of 5 mgd indicated that the canneries were operating around the clock.

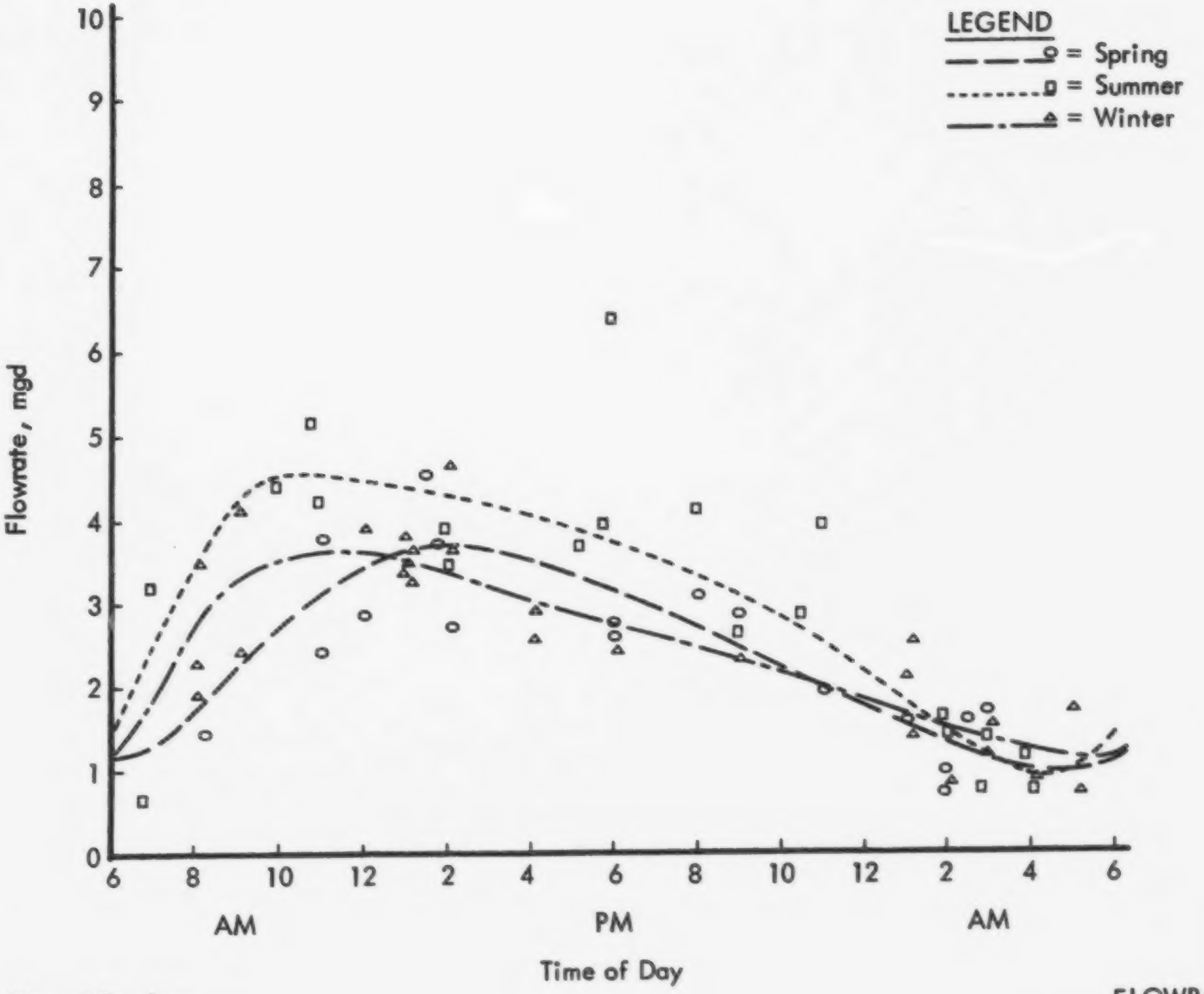
D. SEWAGE GASES

During the Summer Sampling Period, gases within the Southern Industrial Trunk were sampled and analyzed. The gas sampling was done on a hot day (90°F), when sulfide conditions would normally be severe. The canneries provided large flow volumes of wastewater with relatively high BOD and suspended solids.

Samples were taken in special gas sampling tubes on August 25, 1969. (See Photograph III-1.) The gases were collected by inserting a 15-ft-long 1/4-in. diameter plastic tube through a hole in the manhole cover. A 1 cfm vacuum pump extracted the sewer gases for a period of five minutes, through the sampling tube. This sampling procedure insured complete displacement of gases within the evacuated sampling tube. After five minutes, the downstream end of the 500 ml gas sampling tube was closed; the pump continued running until the pressure in the tube reached 20 psi. The upstream end of the gas sample tube was then closed. This sampling process was repeated six times.

The six gas samples were analyzed twice with a gas chromatograph at the project engineer's laboratory on August 26, 1969. Analyses were made for CO_2, O_2, N_2, CH_4, and CO.

As indicated in Table III-3 the oxygen content of the sewer gases was within 2 percent of atmospheric. CO_2 concentrations were 3 to 4 percent by volume. Only at sampling station S-9 was CH_4 detected, and concentrations ranged up to only 1 percent by volume. No CO was detected. N_2 concentration averaged 76 percent by volume.



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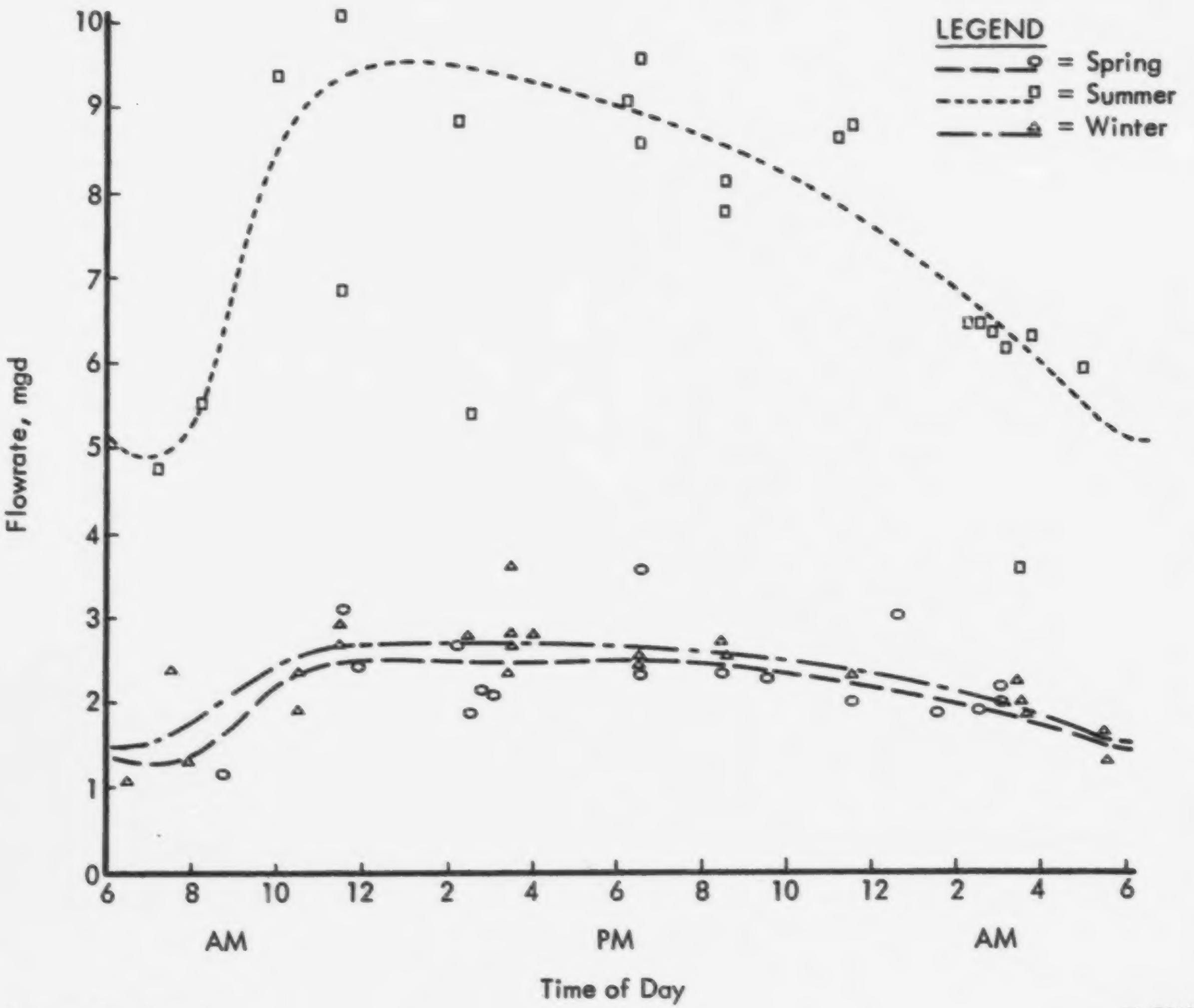
FLOWRATE,
SAMPLING STATION S-9
FIGURE III-2



City of Stockton
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FLOWRATE
SAMPLING STATION S-10
FIGURE III-3

III-1. Taking Gas Samples From the Southern Industrial Trunk

TABLE III-3

ANALYSES OF GASES IN TRUNK SEWER[1]

Sample Station	Tube No.	Percentage Gas by Volume[2]				
		CO_2	O_2	N_2	CH_4	CO
S-10	1	3.6	19.6	76.8	0.0	0.0
S-10	2	3.0	19.9	77.1	0.0	0.0
S-10	3	4.1	20.1	75.8	0.0	0.0
S-9	4	3.7	18.8	76.8	0.7	0.0
S-9	5	3.5	19.6	76.0	0.9	0.0
S-9	6	3.7	19.5	75.8	1.0	0.0

[1] Sampled on August 25, 1969.

[2] Gas chromatograph analysis.

The values summarized in Table III-3 are averages of the two analyses made for each gas sampling tube. These analyses showed that the gases in the sewer had excess CO_2, and that the trunk sewer was not sufficiently vented.

Since the gas chromatograph detection column could not measure sulfides, sulfides were identified qualitatively in the sewer by its characteristic odor and by use of lead acetate paper which slowly turned to a rust color (within 10 minutes), in the presence of hydrogen sulfide gas.

In December 1969, while reconnoitering the sewer, further qualitative tests for hydrogen sulfide using lead acetate paper were performed. The results were similar to those described above; within ten minutes, lead acetate paper turned a light rust color. The characteristic sulfide odor varied from unobservable (the cooked blood type meat packing odor may have overpowered the sulfide odor) to moderately strong septic odor.

E. USEFUL LIFE OF SEWER

Normally, a trunk sewer would be expected to have a life of 30 or more years. However, the waste load discharged from Swift and other industries is exceptionally warm and strong. With normal maintenance, a considerably shorter trunk sewer life should be anticipated due to sulfide gas formation and subsequent aerobic oxidation to sulfuric acid above the flow line. The exact sewer life cannot be predicted because the long-term rate of attack of the hot, strong meat packing wastes on the concrete is not precisely known. Sewer coring was proposed to help estimate the useful life of the sewer, but corings were not done.

In 1969, only isolated corroded areas were observed, probably because of the non-flow and low flow conditions. The City has performed little maintenance on the Southern Industrial Trunk to date. Considerably more maintenance will be required as grease, slimes, and corrosion from Swift industrial waste develop on the walls of the sewer and manhole, and corrosion makes repairs necessary.

Based on the limited field reconnaissance at manholes, the sulfide content of the sewage (ranging up to 5 mg/l) and experiences with comparable concrete sewers at other California communities, the following life expectancies were predicted:

1. 10-year life with normal maintenance.
2. 20-year life with normal maintenance and major repairs.
3. 20-year life with normal maintenance and upstream treatment of Swift waste.
4. 25-year life with normal maintenance and sewer protection.

5. 25-year life with special maintenance and upstream treatment.

6. 30-year life with normal maintenance, sewer protection, and upstream treatment.

F. IN-SEWER TREATMENT AND CORROSION PROTECTION

1. General

In-sewer treatment and protection of the sewer against corrosion are, to a limited extent, closely related; for example, in-sewer treatment will, in addition to reducing the waste load discharged to the downstream treatment plant, keep the sewage fresh, thereby reducing sewer line corrosion. In addition to considering in-sewer treatment, other protective devices were studied, such as hydraulic flushing of the sewer, and lining the sewer with corrosion-resistant material. In-sewer treatment methods reviewed included the addition of chemicals and aeration.

2. Chemicals

Available oxidizing chemicals considered for application to the sewer were hydrogen peroxide, chlorine, and sodium nitrate. Other chemical oxidant possibilities, such as potassium permanganate, are known from waterworks experience to be too costly to warrant serious consideration. The two objectives in applying chemical oxidants are to reduce the existing dissolved sulfides to insignificant levels, and to inhibit the further development of sulfides in a sewer. Normally, it is both uneconomical and unnecessary to achieve complete sulfide removal by oxidation. It is preferable to add only enough chemicals to oxidize the major sulfide content, leaving residual sulfide concentrations which are tolerable. Table III-4 summarizes other studies using oxidizing chemicals for control of sulfides.

Chlorine has had extensive use in sewage sulfide control. The costs of treatment with chlorine and peroxide are about equal. Treatment with sodium nitrate is less costly, but it could increase nitrogen concentrations which might compound the present waste nutrient discharge control problems.

These treatment costs were computed assuming chemicals were applied in proportion to flow. In order to reduce costs, shock doses and/or other methods can be employed. Laboratory and field test work done using hydrogen peroxide at low dosages is described in Chapter V.

Based on preliminary studies, hydrogen peroxide appeared to have the unique capabilities of being consumed slower than other chemicals, and of more effectively reducing slime growths which generate sulfides. Hydrogen peroxide breaks down in sewage to release molecular oxygen due to the action of the enzyme catalase and a heavy metal catalyst such as iron. Apparently the H_2O_2 molecule has an inhibitory effect on the

TABLE III-4

SUMMARY OF POTENTIAL OXIDIZING CHEMICALS FOR SULFIDE CONTROL

Item	Chlorine	Sodium Nitrate	Hydrogen Peroxide
Form of Chemical as Purchased	Liquid chlorine in ton containers (bulk contract)	Bulk, crystal salt via freight car or cargo ship	35 to 70 percent H_2O_2 in 8,000 gal minimum tank cars (railroad)
Estimated Unit Price, (¢/lb)			Sliding Scale, depending on use
Gross Weight Basis	5.0	4.0	7 - 17 (delivered)
100% Strength Basis	5.0	4.0	20 - 24 (delivered)
Method of Storage	Ton containers, from supplier	Hoppers and/or tanks	Stainless steel tanks
Method of Feeding	Evaporators and Chlorinators	Dry or Solution	Proportioning Pumps
Average Dose, ppm	33	28	8
Peak Dose, ppm	47	42	12
Chemical Dose, lb/mgd	270	230	70
1,000 lb/yr/mg	100	80	25
Annual Chemical Cost, $1,000/mgd	5	3	5
Facilities necessary for receiving, storing, handling, and feeding chemical	Local chlorination bldg.; scales, evaporators, and chlorinators; natural gas, water, chlorine, and chlorine solution piping; controls	Local transfer facilities from rail siding or pier to local dry storage; dissolving tanks; solution feeders; controls	Tank truck for bulk transfer from rail siding to application points; stainless steel storage tanks; feeding and diluting facilities; controls

TABLE III-4 (Continued)

SUMMARY OF OTHER CHEMICALS FOR SULFIDE CONTROL

Item	Chlorine	Sodium Nitrate	Hydrogen Peroxide
Prospects for sulfide control	Good	Questionable; requires long detention time	Promising
Experience Record	Considerable	Limited to several tests on sewers; used occasionally in overloaded oxidation ponds to prevent septicity	None on full scale

sulfur bacteria that reduce sulfate to sulfide. In jar tests for another study, there was no increase in solution phase sulfide over a two-hour period after oxidation with hydrogen peroxide, whereas in similar tests using chlorine, there was an increase in the sulfide content after the initial reduction.

The hydrogen peroxide also appeared to condition the raw sewage so that there could be improved treatment plant efficiency.

As described in Chapter V, the field scale test addition of hydrogen peroxide to the Swift wastewater proved to be ineffective. The half-life of hydrogen peroxide in the raw Swift wastewater was 4 to 6 minutes. Within 15 minutes after application of 10 mg/l H_2O_2, it was entirely consumed. In less than 30 minutes measurable amounts of sulfides were being generated. The high iron blood content of the meat packing waste was believed to be the cause of the excessive peroxide demand.

It can be assumed that other oxidizing chemicals also would be consumed quickly by the raw Swift wastewater and would therefore not provide economical control of sulfides.

In laboratory tests, it was found that when preceded by good aeration, the addition of hydrogen peroxide to Swift wastewater was effective in oxidizing sulfides. It can be assumed that chlorine and sodium nitrate would also be effective if the wastes were pretreated. In conclusion, oxidizing chemicals would be technically feasible for protecting the sewer if the Swift wastewaters are first pretreated at an upstream activated sludge plant, but cannot be considered for practical use on the raw wastes. Based on these findings, a preliminary design was prepared for applying hydrogen peroxide to protect properly pretreated waste flows along the entire 40,351 ft length of the Southern Industrial Trunk. Three feed stations would be required. The first station would be at Airport Way, about 12,700 ft downstream from the Swift plant. The second feed station would be about 8,000 ft downstream of Airport Way, and the third would be on Eighth Street near Argonaut Street, which is 18,000 ft downstream of Airport Way and 10,500 ft upstream of the Main Water Quality Plant.

Presented in Appendix E are the design criteria for applying hydrogen peroxide and cost estimates for construction and operation of three feed stations. Hydrogen peroxide additions at the rates prescribed in the design criteria should extend the life of the trunk sewer to at least 30 years with normal maintenance. The hydrogen peroxide facilities construction costs were estimated to be $70,400 and annual costs were estimated to be $27,700.

Alkaline chemicals considered for possible application to control sulfides were lime and caustic soda, either as commercial chemicals or as alkaline by-product residues from waste process materials such as the sludge from acetylene manufacturing. The two major beneficial effects of alkaline chemicals are: 1) their inhibition of sulfide producing microorganisms and 2) the elevation of pH in the wastewater, thereby reducing the proportion of dissolved sulfide that is present in the un-ionized form.

Many metallic sulfide salts such as iron, lead, and zinc, are insoluble. Thus, when soluble salts of these latter metals are introduced into sulfide-containing wastewater, they will normally precipitate out the sulfide in a harmless solid form.

In certain industrial areas, waste pickle liquors are sometimes available for low cost municipal wastewater treatment. Such pickle liquors, although acidic, contain sufficient ferric or other compounds to beneficially precipitate dissolved sulfides in the flowing wastewater.

The potential value of using these alkaline and precipitating chemicals are summarized in Table III-5. None of these chemical treatments appear promising for use at Stockton, unless further testing is performed to define quantitatively, the technical and cost factors, and to find a source of suitable waste liquors at little or no cost.

3. Aeration

Alternative methods of oxidizing sulfides and keeping sewage fresh are by applications of compressed air or pure oxygen. This can be accomplished by two methods. The first method would be to install weirs in the sewer to back-up the flow and therefore cause the sewer to flow 3/4 to 7/8 full. Air piping would be installed in the invert of the sewer and compressed air or liquid oxygen diffused into the sewage to increase the dissolved oxygen content. The distribution system would be installed in specified sections of the sewer, preceded and followed by sections without oxygenation works. After increasing the dissolved oxygen content in the oxygenation section of the sewer, the sewer can be allowed to flow normally until the dissolved oxygen level drops to less than 1 mg/l, at which point another section of piping would be installed. The primary drawback of an aeration system is the low rate of oxygen transfer, which would probably be in the neighborhood of 1 percent. Consequently, the number of blowers and length of air piping would be excessive. Another consideration was the problem of venting and filtering the odorous gases. Tests using this principle for keeping sewage fresh were not successful. The liquid oxygen system would also present difficulties. Preliminary cost estimates for both construction and operation by either oxygenation procedure indicated that the costs were much higher than with other available protection methods.

A more promising method of aeration is the installation of U-Tubes at several points in the Southern Industrial Trunk. This type of aeration system is simple in concept and basically consists of two elements: a device for entraining air or oxygen into the flowing wastewaters; and a vertical U-shaped flow path to provide residence time in a zone of above atmospheric pressure during which oxygen absorption and saturation can take place. Oxygen can be entrained either by introducing air or pure oxygen through a diffuser system. For the Stockton application, a compressor or blower was

TABLE III-5

SUMMARY OF OTHER CHEMICALS FOR SULFIDE CONTROL

Item	Chemical Additives				
	Alkaline Type			Precipitating Type	
	NaOH	$Ca(OH)_2$	Waste	Pickle Liq.	Other
Possible Advantages for Implementing	--	--	Low cost if available as waste	Low cost if available as waste	--
Probable Disadvantages for Implementing	High cost and interfere w/ digestion	High cost, sludge, and interfere w/digestion	None known	None known	None known
Experience Record of Method in Comparable Applications	None known	None known	Limited	Limited	Limited
Prospects for Success	Fair	Fair	Fair	Fair	Varies
Range of Annual Cost, $1,000/mgd	2 - 4.5	2 - 4.5	No data available	No data available	No data available

considered desirable to introduce air. A schematic illustration of the U-Tube concept is shown on Figure III-4.

The U-Tube method is particularly well suited to raise the dissolved oxygen concentration of water or sewage from a low value to a value approaching saturation within a relatively short residence time. A U-Tube aeration system requires little space, can be designed with no moving parts (except for the blower), and requires nominal labor for operation and maintenance.

Experimental and analytical tests have been undertaken to investigate and demonstrate the U-Tube aeration concept.[1,2,3,4] In the design of a U-Tube there are four parameters which can be varied independently; these are the air-to-water ratio, influent dissolved oxygen concentration, depth of U-Tube, and water velocity or resident time through the U-Tube. Other factors to be considered in the design are sediment by-pass of the U-Tube, system head loss, point of air application, and desired concentration of dissolved oxygen in the effluent.

For use in an existing gravity sewer, the system head loss must be minimized or a pump installed. To minimize head losses, the air diffuser should be installed in the lower reaches of the downward leg of the U-Tube. This would require relatively high air pressures,which would increase the cost for operating the blower. As a trade off, especially when there is excess head available, air can be applied under minimum pressure (1 psi) at the upper end of the downstream leg of the U-Tube, minimizing air blower operating costs and increasing oxygen transfer efficiency due to longer residence time.

Another benefit from U-Tube operation is the nitrogen stripping ability. Nitrogen levels may be decreased 1 to 3 mg/l with each passage through a U-Tube.

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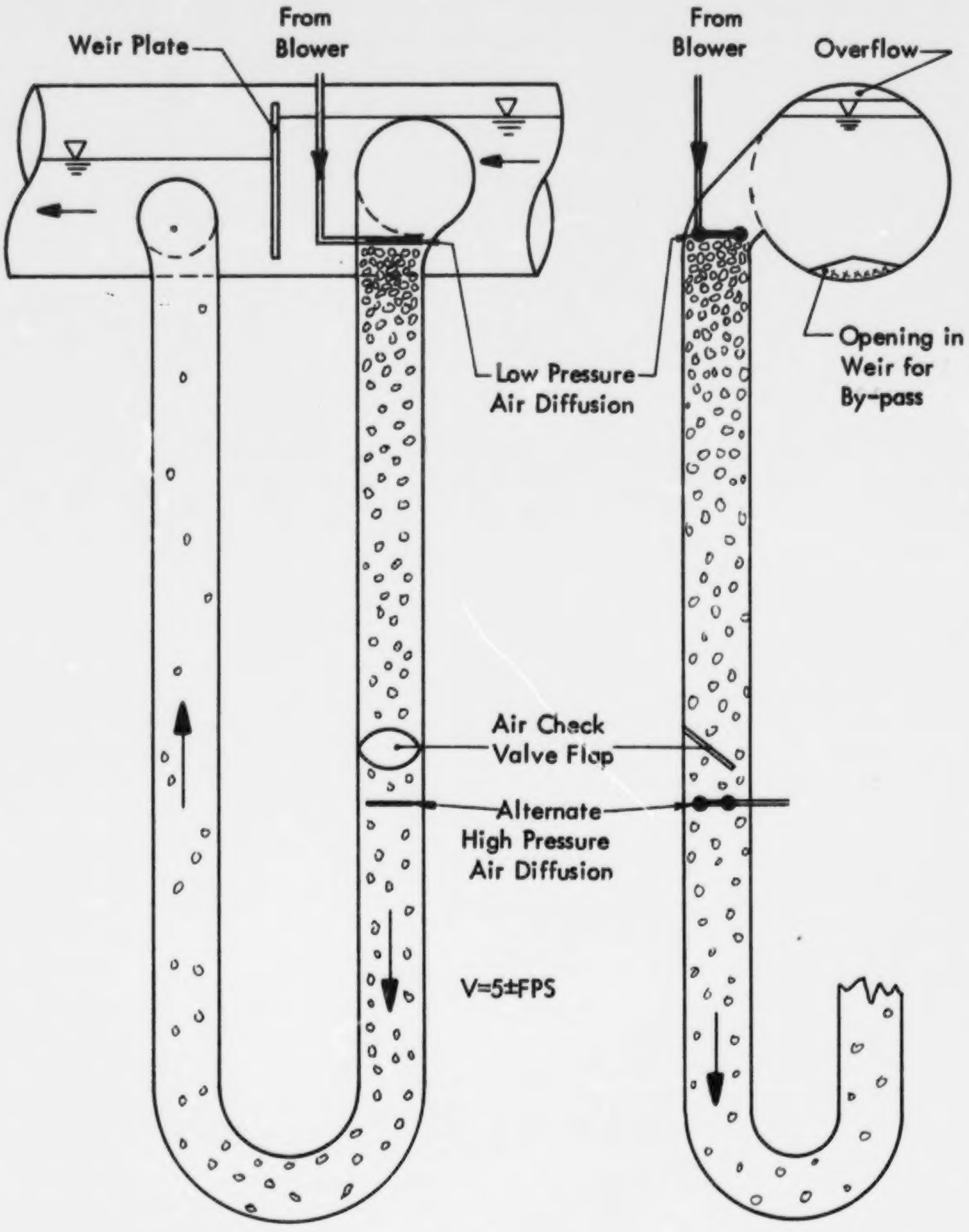
[1] Bruijn, Jacob and Tuinzaad; Hendrice, "The Relationship Between Depth of U-Tubes and the Aeration Process", Journal, American Water Works Association, p. 876-883, July 1958.

[2] Speece, I. E.; Adams, Jack L.; and Wooldridge, Caroline B., "U- Tube Aeration Operating Characteristics", Journal of Sanitary Engineering Division, ASCE 95 SA3, p. 563-574, June 1969.

[3] Speece, R. E. and Orosco, Rudolph, "Design of U-Tube Aeration Systems", Presented at the ASCE Symposium on Sanitary Engineering Research, Development and Design, Cornell University, July 1969.

[4] Mitchell, R. C. and Lev, A. D., Rocketdyne, A Division of North American Rockwell Corp., The U-Tube for Water Aeration, Preliminary Draft of Final Report, Federal Water Pollution Control Administration, October 1969.


Weir Plate
From Blower
From Blower
Overflow
Opening in Weir for By-pass
Low Pressure Air Diffusion
Air Check Valve Flap
Alternate High Pressure Air Diffusion
V=5±FPS

City of Stockton
Swift & Co. - FWPCA Project

U-TUBE SCHEMATIC
FIGURE III-4

It is important when employing a U-Tube in a gravity sewer to by-pass sediment in order to prevent clogging. The design (see Figure III-4) proposed for use at Stockton would consist of a weir plate with an opening at the bottom to by-pass the sediment. Additionally, overflow would allow passage of peak flows. A scour velocity of about 3 to 5 ft/sec should be maintained in the U-Tube.

The design criteria for application of the U-Tube concept for the Southern Industrial Trunk were developed assuming two alternate conditions: 1) an upstream pretreatment activated sludge plant; and 2) no upstream treatment plant. With the upstream treatment plant, five U-Tube stations would be required; without the upstream treatment plant, at least six stations would be needed and possibly more due to the oxygenation characteristics of the Swift wastewater. The oxygen transfer through a 40-ft deep U-Tube was estimated to be 60 to 70 percent of saturation. The oxygen demand for the pretreated and untreated wastewater was assumed to be 3 and 7 mg/l per hour, respectively.

The complete design criteria are presented in Appendix F, along with estimates for construction and annual costs. Cost of construction of five U-Tube stations, following upstream treatment, was estimated to be $127,800. For six stations without upstream treatment, construction costs were estimated to be $157,700. Annual costs were estimated as $18,900 and $26,300, respectively.

Use of five U-Tubes with upstream activated sludge treatment would extend the sewer life to at least 30 years. Use of six U-Tubes without upstream treatment would probably extend the life of the sewer to 20 years with normal maintenance and possibly 30 years with special maintenance.

4. Hydraulic Flushing

The major cause of concrete sewer corrosion is sulfuric acid resulting from the oxidation of hydrogen sulfide gas. The sulfuric acid reacts with the concrete and/or iron to destroy the structural integrity of the concrete pipe. The warm, damp atmosphere within the sewer line accelerates the reactions. Most of the corrosion occurs above the water line of the sewer, and is most severe at the crown of the pipe.

Hydraulic flushing can be used to clean the crown and other sewer pipe surfaces above the normal water line, thus washing away the acid prior to the occurrence of concentrated corrosion.

Periodic flushing can be performed by a relatively simple inflatable dam installed within the sewer line. During periods of normal and peak flows the dam would be deflated and lie on the bottom and sides of the sewer. When deflated it would cause insignificant head loss. By means of time clocks and/or level controls, a small compressor can be activated to inflate the dam for flushing during periods of low flow.

The dam would be installed at a manhole so that when the liquid level reaches a designated point the sewage will overflow the dam and continue through the pipeline. The dam would extend above the invert of the sewer so that wastewater would back up several feet into the manhole. After the pipeline has been washed for a predetermined duration, the dam would automatically deflate and the sewage thereafter would flow normally through the sewer.

A Fabridam is a device used for this purpose. It is manufactured by Firestone Coated Fabrics Company and is a rubber-coated fabric. A Fabridam was first installed in 1957 in Los Angeles. These devices have since been used primarily for temporary damming of rivers and flood control structures. At present there is only one application of a Fabridam in a sewer. It has been in use for about three years in Minnesota. Several communities in California are considering installation of Fabridams in sewers, but none have been installed to date (1970). Application of a Fabridam to a sewer is illustrated in Photographs III-2 and III-3.

To protect the Southern Industrial Trunk, 10 inflatable dams would be required: 2 for the 10,509 ft length of 48-in. RCP, 3 for the 17,925 ft length of 42-in. RCP, and 5 for the 11,917 ft length of 30-in. RCP. Although there have been no long-term sewer experiences with Fabridams, it is anticipated that the life of the Southern Industrial Trunk could be extended at least 10 years by its use in conjunction with normal maintenance, and 20 years in conjunction with special maintenance. The cost to construct the 10 Fabridams was estimated to be $88,200; the annual cost was estimated to be $16,000. (See Appendix G.)

5. Sewer Lining

Another potential method of extending the life of the Southern Industrial Trunk is by providing a non-corrosive liner. In the last two years, a fiberglass-reinforced plastic mortar pipe referred to as Techite has been marketed. It can be used for water services, sewer force mains, gravity sewers, and as sewer liners. As a liner, it would be installed after the sacrificial concrete has been corroded from the sewer, but prior to loss of significant pipe structural strength.

If in 1970, in lieu of replacing a badly corroded trunk sewer, the City of Stockton installed a 33-in. Techite pipe liner in the 36-in. trunk sewer, the installed cost would be about $31/linear-ft or $0.94 for each inch of diameter/linear-ft, considerably less than the cost of pipe replacement. In the City of Modesto, located 50 miles south of Stockton, an 18-in. diameter Techite pipe liner was installed to protect a badly corroded 24-in. concrete sewer.[1] Unit costs for the completed installation of the sewer liner were reported to be $11/linear-ft or $0.61/in. of diameter/linear-ft.

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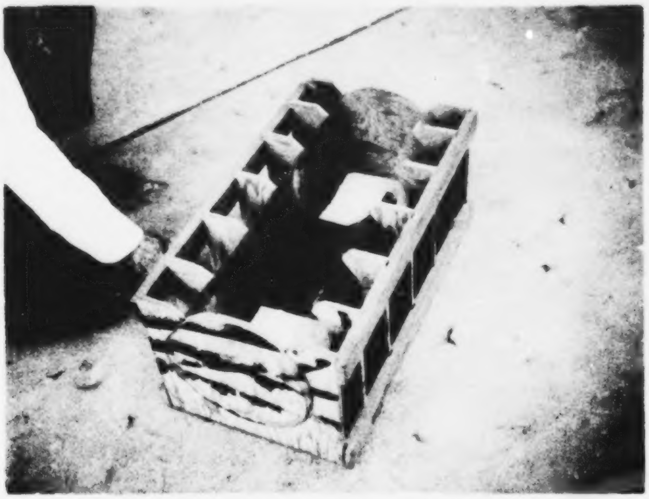
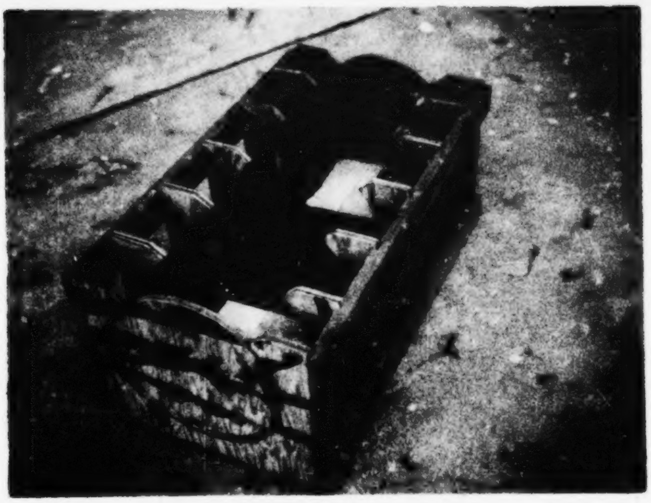
[1] Reynolds, Frank R., "New Life for a Sewer and--Money in the Bank", Public Works, p. 84-85, Vol. 100, November 1969.



III-2. Fabridam Inflated in Sewer Mock-Up



III-3. Deflated Fabridam Lying Flat on Bottom and Sides of Sewer Mock-Up

Since Techite pipe is a relatively new product, it has not had an opportunity to demonstrate life expectancy. The inert raw materials--fiberglass, sand, and isophthalic resin--exhibit a high degree of resistance to chemical attack. Techite pipe can meet the requirement for acid resistance set forth in ASTM Specification C-200 applicable to extra strength clay pipe. The manufacturer predicts a life of 50 or more years under normal service use. The Techite liner is lightweight and can be jacked through the sewer while in use. A major disadvantage of the Techite liner is that it reduces the sewer diameter. However, the smooth interior surface (n=0.012 for the liner vs. n=0.013 for the original sewer) partially compensates for the reduced size. The Techite may split or peel and requires careful manufacturing control.

It is expected that the Southern Industrial Trunk could be used for another 10 years before lining with a Techite pipe.

IV. MAIN WATER QUALITY CONTROL PLANT

A. DESCRIPTION

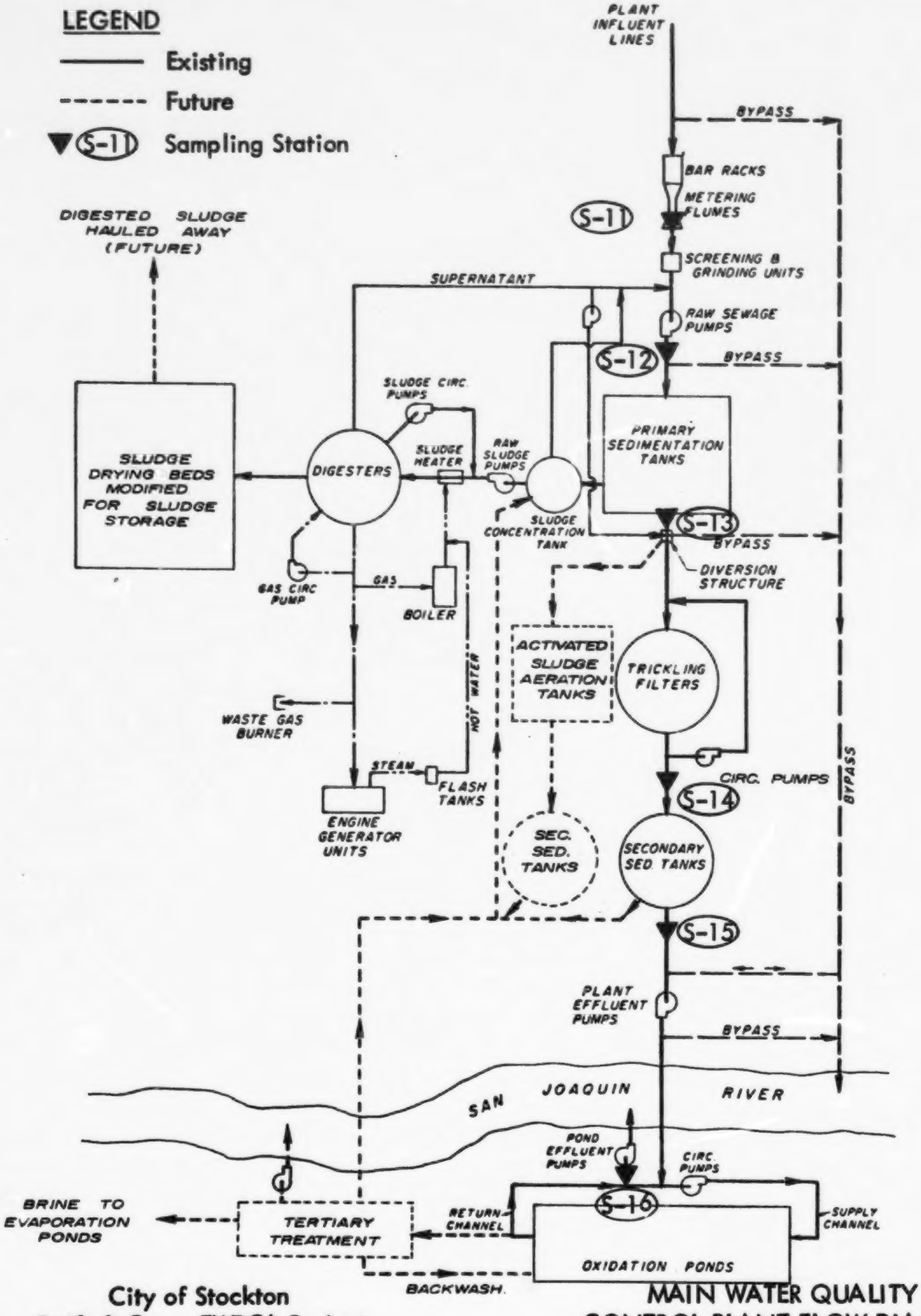
The City of Stockton's Main Water Quality Plant is located in the western section of the City on Charter Way, adjacent to the San Joaquin River. Its general position, with respect to the City proper and the Swift meat packing facility, is shown on Figure II-1. The treatment plant presently serves approximately 90 percent of the area sewered within the Stockton City limits. It also serves the Port of Stockton and three small independent sewerage districts. The basic plant, as presently constituted, was constructed in the 1946-1948 period. Since then, additional facilities have been constructed to handle the increased sewage flows generated by the growing population and industrial expansion.

Figure IV-1 presents the plant flow diagram. Specific elements of the plant flow are meters, screening and grinding equipment, raw sewage pumps, primary sedimentation tanks, trickling filters, secondary sedimentation tanks, digestors, sludge drying beds, oxidation ponds, and disinfection facilities. Table IV-1 lists the sizes and capacities of the principal treatment plant units.

Figure IV-2 shows the plant layout, with the existing facilities delineated as solid lines and proposed facilities as dashed lines. By means of effluent pumping stations and piping, the secondary effluent is transported under the San Joaquin River to oxidation ponds. Generally, the ponds provide treatment in series and prevent short-circuiting. Pond effluent is discharged to the river through the pond effluent pumping plant. Photographs IV-1 and IV-2 are panoramic views of the treatment plant and the oxidation ponds, respectively. Photographs IV-3 and IV-4 show the oxidation ponds' outlet structure into the San Joaquin River.

In 1969, the California State Central Valley Regional Water Quality Control Board adopted more rigid wastewater discharge requirements for the City of Stockton (see Appendix A). These requirements, coupled with increased flow from the growing population and industrial expansion, require the City to improve and expand the existing sewage treatment works. Additional secondary treatment facilities including activated sludge tanks, sludge thickeners, digestors, oxidation ponds, and tertiary treatment works, will be required. Denitrification and demineralization facilities may also be required, but will depend on the results of further comprehensive water quality and water flow studies of the San Joaquin Delta.

Historical costs for constructing the present plant and the estimated costs for plant expansion and improvement are summarized in Table VII-1. The proposed five-year plant expansion program cost could be equal to the original plant construction cost.


LEGEND
Existing
Future
S-11 Sampling Station
PLANT INFLUENT LINES
BYPASS
BAR RACKS
METERING FLUMES
S-11
SCREENING & GRINDING UNITS
RAW SEWAGE PUMPS
S-12
BYPASS
DIGESTED SLUDGE HAULED AWAY (FUTURE)
SUPERNATANT
SLUDGE CIRC. PUMPS
SLUDGE DRYING BEDS MODIFIED FOR SLUDGE STORAGE
DIGESTERS
SLUDGE HEATER
RAW SLUDGE PUMPS
SLUDGE CONCENTRATION TANK
PRIMARY SEDIMENTATION TANKS
S-13
BYPASS
DIVERSION STRUCTURE
GAS CIRC PUMP
GAS
BOILER
HOT WATER
ACTIVATED SLUDGE AERATION TANKS
TRICKLING FILTERS
WASTE GAS BURNER
STEAM
FLASH TANKS
CIRC. PUMPS
BYPASS
S-14
ENGINE GENERATOR UNITS
SEC. SED. TANKS
SECONDARY SED TANKS
S-15
PLANT EFFLUENT PUMPS
BYPASS
SAN JOAQUIN RIVER
POND EFFLUENT PUMPS
CIRC. PUMPS
S-16
BRINE TO EVAPORATION PONDS
TERTIARY TREATMENT
RETURN CHANNEL
SUPPLY CHANNEL
OXIDATION PONDS
BACKWASH

City of Stockton
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MAIN WATER QUALITY CONTROL PLANT FLOW DIAGRAM

FIGURE IV-1

TABLE IV-1

SIZES AND CAPACITIES OF PRINCIPAL UNITS, MAIN WATER QUALITY CONTROL PLANT[1]

Influent sewers	
Capacity without surcharge, mgd	
Charter Way, 30"	7.2
Charter Way - Worth St., 48"	21
Southern Industrial, 48"	16
Total, all influent lines	43.2
Bar racks	
Number	3
Width, ft	4.0
Water depth, ft	2.6
Grit removal channels	
Number	3
Width, ft	4.0
Max depth, ft	5.4
Parshall flumes	
Number	3
Throat width, ft	2.0
Max rate, each flume, mgd	20
Head at max rate, ft	2.4
Comminuting units	
Number	3
Channel width, ft 2 channels	4
1 channel	5
Raw sewage pumping units	
Number	4
Capacity, all pumps operating[2], mgd	93
Capacity, largest pump not operating, mgd	59
Power generation units[3]	
Number	2
Horsepower each	600
Primary sedimentation units	
Rectangular tanks	
Number	4
Width, ft	37
Length, ft	141
Average water depth, ft	15
Capacity at 2 hr detention, mgd	
Each tank	7.0

TABLE IV-1 (Continued)

SIZES AND CAPACITIES OF PRINCIPAL UNITS, MAIN WATER QUALITY CONTROL PLANT[1]

Square tanks	
Number	2
Width, ft	70
Average water depth, ft	14
Capacity at 2 hr detention, mgd	
Each tank	6.1
Total capacity of all tanks, 2 hr detention, mgd	40.2
High-rate trickling filters	
Number	6
Diameter, ft	166
Average rock depth, ft	4.2
Volume of rock per filter, 1000 cu yd	3.36
Filter circulation pumping units	
Number	4
Capacity, all pumps operating, mgd	30
Secondary sedimentation units	
Number	4
Diameter, ft	100
Side water depth, ft	12
Capacity at 2 hr detention, mgd	
Each tank	8.5
Total	34
Sludge digestion tanks[4]	
Number (2 primary, 1 secondary)	3
Diameter, ft	100
Side water depth, ft	30
Total volume of all tanks, 1000 cu ft	705
Sludge concentration tank	
Diameter, ft	70
Side water depth, ft	10
Capacity at 3 hr detention, mgd	2.3
Plant effluent pumping units	
Old station[5]	
Number	2
Capacity, both pumps operating, mgd	32
New station[6]	
Number	2
Capacity, both pumps operating, mgd	68
Total capacity, all pumps operating, mgd	100

TABLE IV-1 (Continued)

SIZES AND CAPACITIES OF PRINCIPAL UNITS, MAIN WATER QUALITY CONTROL PLANT[1]

Oxidation pond circulation pumping units	
Number	3
Capacity, mgd	
Each	65
Total	195
Oxidation ponds	
Number	4
Area, effective total, acres	630
Design water depth, ft	4.5
Volume, based on design water depth, mg	1,320
Oxidation pond effluent pumping units	
Number	4
Capacity, total, mgd	56

---

[1] From "Stockton Sewerage Survey", by Brown and Caldwell, Consulting Engineers, 1965 and updated for additions through 1969.

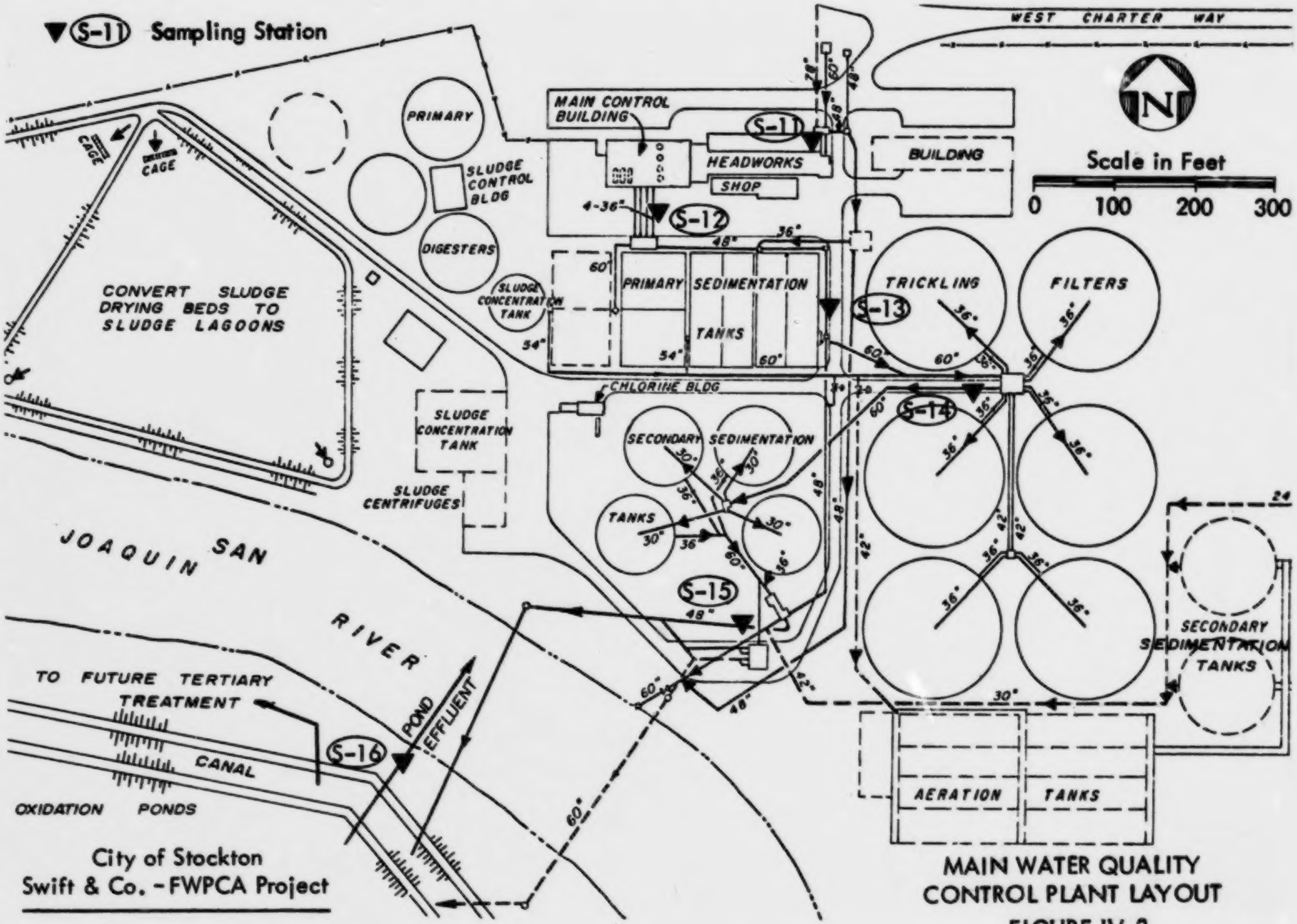
[2] Capacities of individual pumps: 34, 34, 15, and 10 mgd.

[3] Each unit generates sufficient power to drive 1-34 mgd raw sewage pump, 1-34 mgd secondary effluent pump and the 4 filter circulation pumps.

[4] Primary tanks are heated, secondary is not heated.

[5] At present used to return secondary effluent to filter influent line.

[6] Pumps secondary effluent to oxidation return channel.

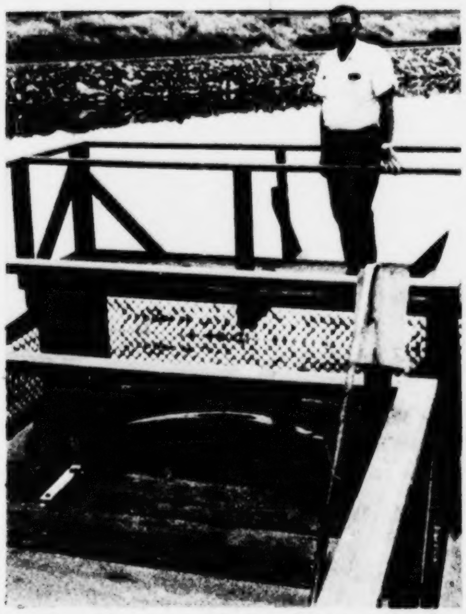

▼(S-11) Sampling Station
WEST CHARTER WAY
N
Scale in Feet
0 100 200 300
MAIN CONTROL BUILDING
HEADWORKS
SHOP
BUILDING
S-11
S-12
S-13
S-14
S-15
S-16
4-36"
48"
36"
60"
54"
PRIMARY SEDIMENTATION TANKS
PRIMARY
SLUDGE CONTROL BLDG
DIGESTERS
SLUDGE CONCENTRATION TANK
CHLORINE BLDG
TRICKLING FILTERS
SECONDARY SEDIMENTATION TANKS
AERATION TANKS
SLUDGE CONCENTRATION TANK
SLUDGE CENTRIFUGES
CONVERT SLUDGE DRYING BEDS TO SLUDGE LAGOONS
CAGE
CAGE
SAN JOAQUIN RIVER
POND EFFLUENT
TO FUTURE TERTIARY TREATMENT
CANAL
OXIDATION PONDS
30"
42"
24
City of Stockton
Swift & Co. - FWPCA Project

MAIN WATER QUALITY
CONTROL PLANT LAYOUT
FIGURE IV-2

IV-1. Main Water Quality Control Plant With San Joaquin River in Foreground (Photographed From Oxidation Ponds)

IV-2. Oxidation Ponds With Effluent Pump Station in Foreground.

IV-3. River Outlet From Oxidation Ponds.



IV-4. Close-up View of River Outlet Structure.

City of Stockton
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PHOTOGRAPHS

B. PLANT OPERATIONS

The plant is well operated by a regularly assigned staff of 18 men, including a chemist and two laboratory technicians; they analyze and record samples obtained from the process units and receiving waters of the San Joaquin River. The treatment plant is attended 24 hours per day. The appearance of process units and mechanical equipment is generally good.

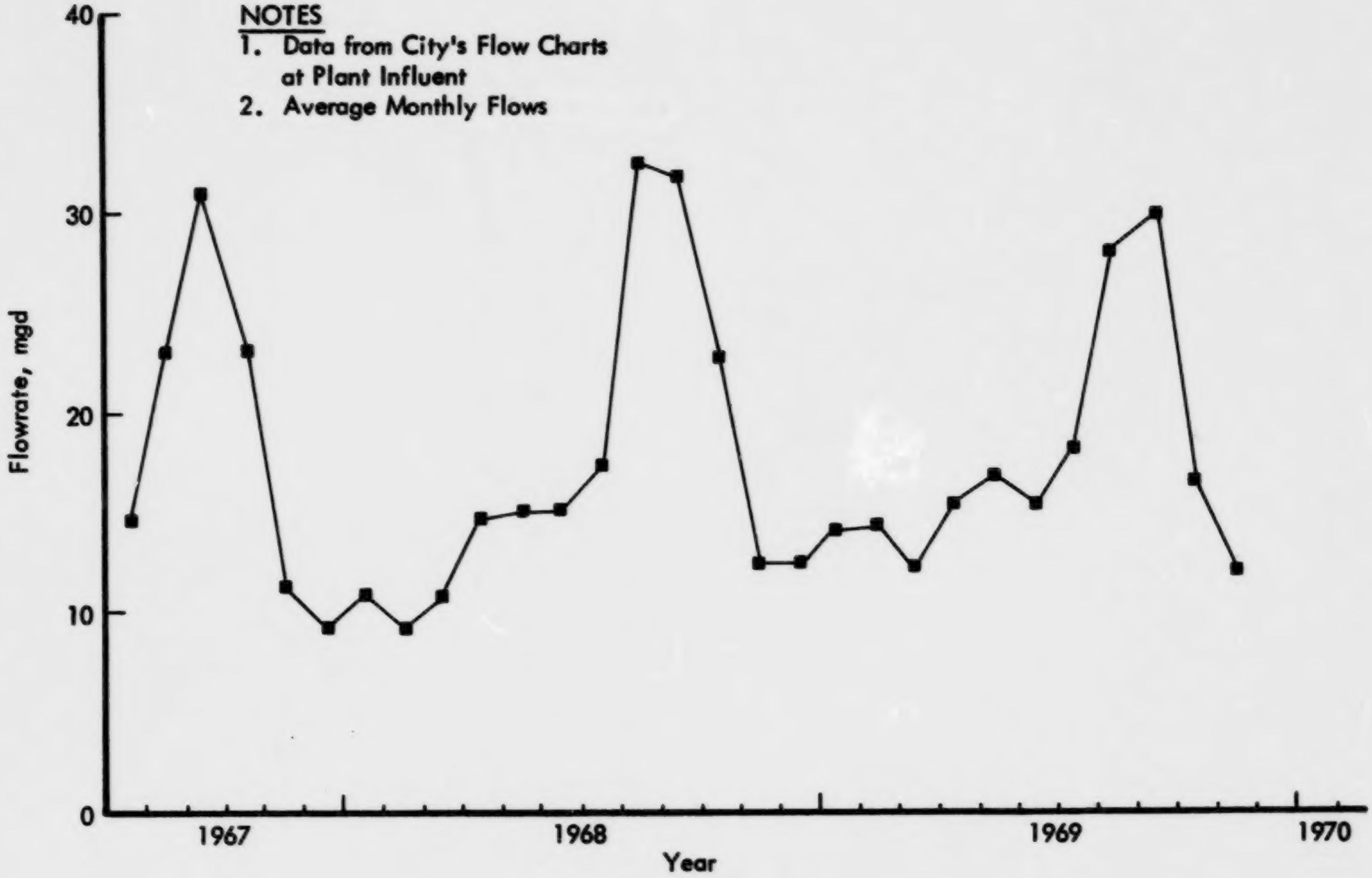
The quantity and pollution load of sewage discharged to the City of Stockton's Main Water Quality Plant varies seasonally, largely because of waste discharges from the canneries during their heavy processing period from August to October and sewer infiltration from heavy rainfall during the period from December through March.

Figures IV-3 through IV-6 illustrate the wide variations in flow quantities, BOD, and suspended solids. Normal dry weather flows averaged 14 to 15 mgd. Daily flows during the canning season averaged about 33 mgd and ranged up to 39 mgd. Daily flows during heavy rains ranged up to 28 mgd. Peak instantaneous flowrates of 43 mgd were recorded during the canning season and during heavy rains. Figure IV-4 shows hourly flows for a typical week during and after the canning season. These curves illustrate the volume differential caused by cannery industrial wastewater.

As is the case with flow volume, the organic load exhibited hourly, daily, and seasonal variations. The latter were also due primarily to waste discharges from the canneries. The plant treatment operations, including past and future plant expansion needs, are primarily the result of increased seasonal waste flows from the food processing industry.

The existing primary sedimentation units, trickling filters, and secondary sedimentation units consistently provide 80 to 90 percent BOD removal efficiency except during the peak canning season, when the plant overload causes 65 to 70 percent waste treatment efficiency. The oxidation ponds are then essential in achieving more than 90 percent BOD reduction throughout the canning season. The oxidation ponds have provided the necessary detention time and treatment to allow BOD removal efficiency averaging 94 percent over the past 2-1/2 years. In 1969, with the addition of a fourth oxidation pond, average BOD removal was 97 percent. The monthly variations and BOD removals are illustrated on Figure IV-5. Suspended solids concentrations in the influent and effluent are shown in Figure IV-6. Suspended solids removals averaged approximately 80 percent year-round for the past 2-1/2 years. The concentration of suspended solids in the influent and in the effluent were approximately twice as high during the canning season as during the non-canning season. Tables IV-2 and IV-3 summarize the influent and effluent characteristics for the July 1967 through February 1970 period.

Costs for operation and maintenance of the Main Water Quality Plant for fiscal year 1969-70 are given in Table VII-1. Including administrative and sewer service charge



NOTES
1. Data from City's Flow Charts at Plant Influent
2. Average Monthly Flows

City of Stockton
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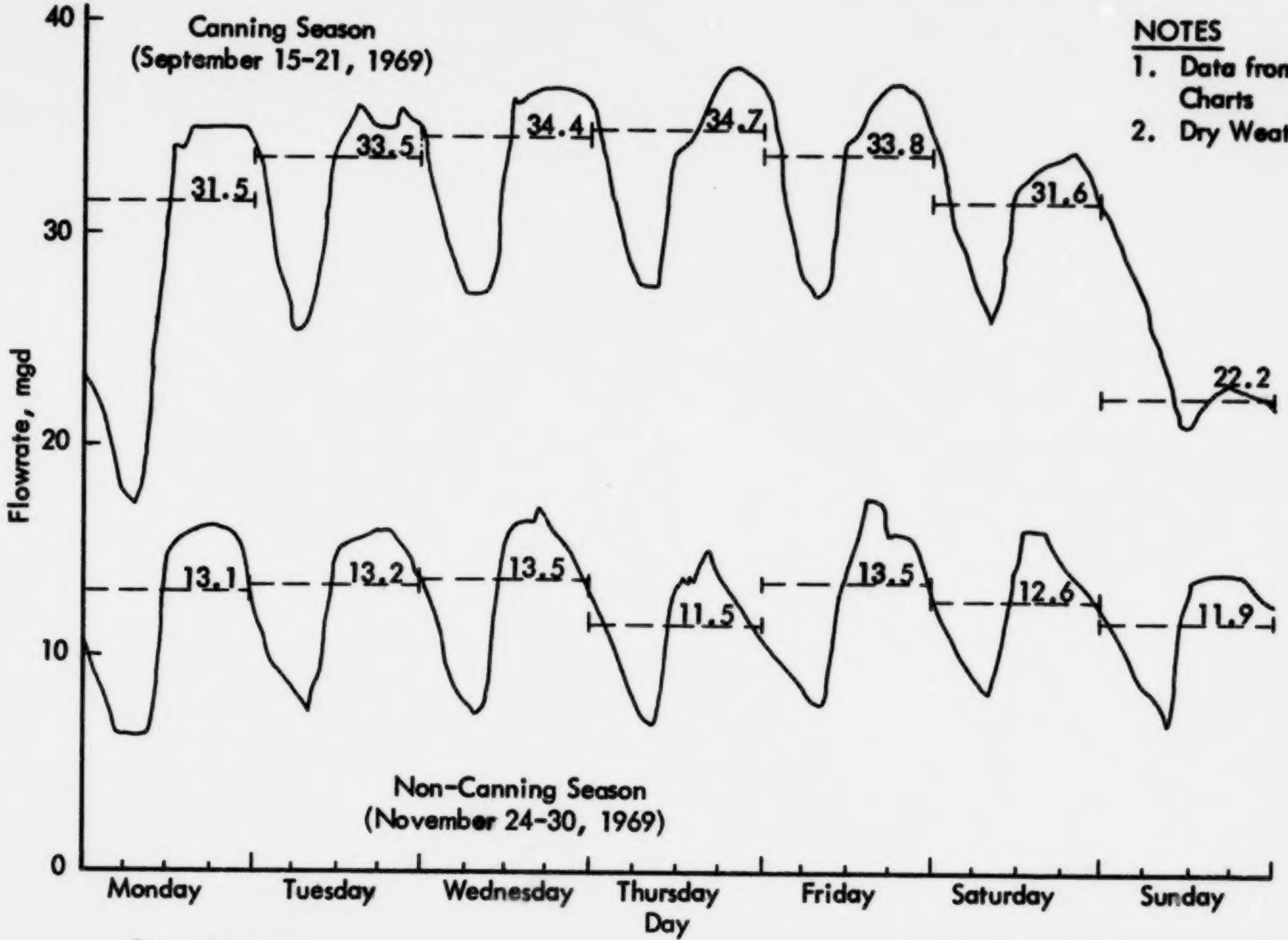
FLOWRATES
MAIN WATER QUALITY CONTROL PLANT

FIGURE IV-3



NOTES
1. Data from City's Flow Charts
2. Dry Weather Conditions

City of Stockton
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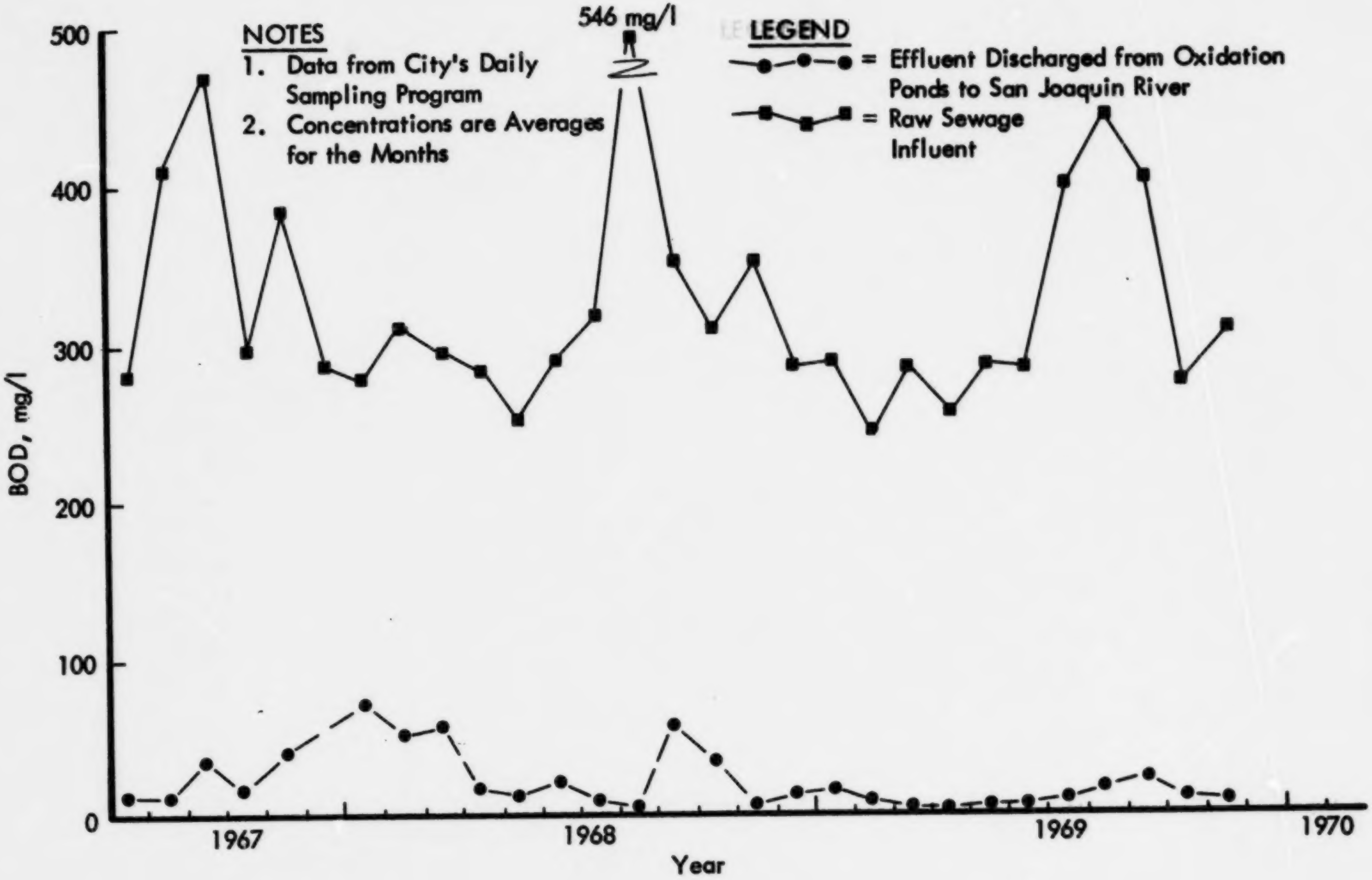
FLOWRATE VARIATIONS OVER TYPICAL WEEKS
MAIN WATER QUALITY CONTROL PLANT

FIGURE IV-4



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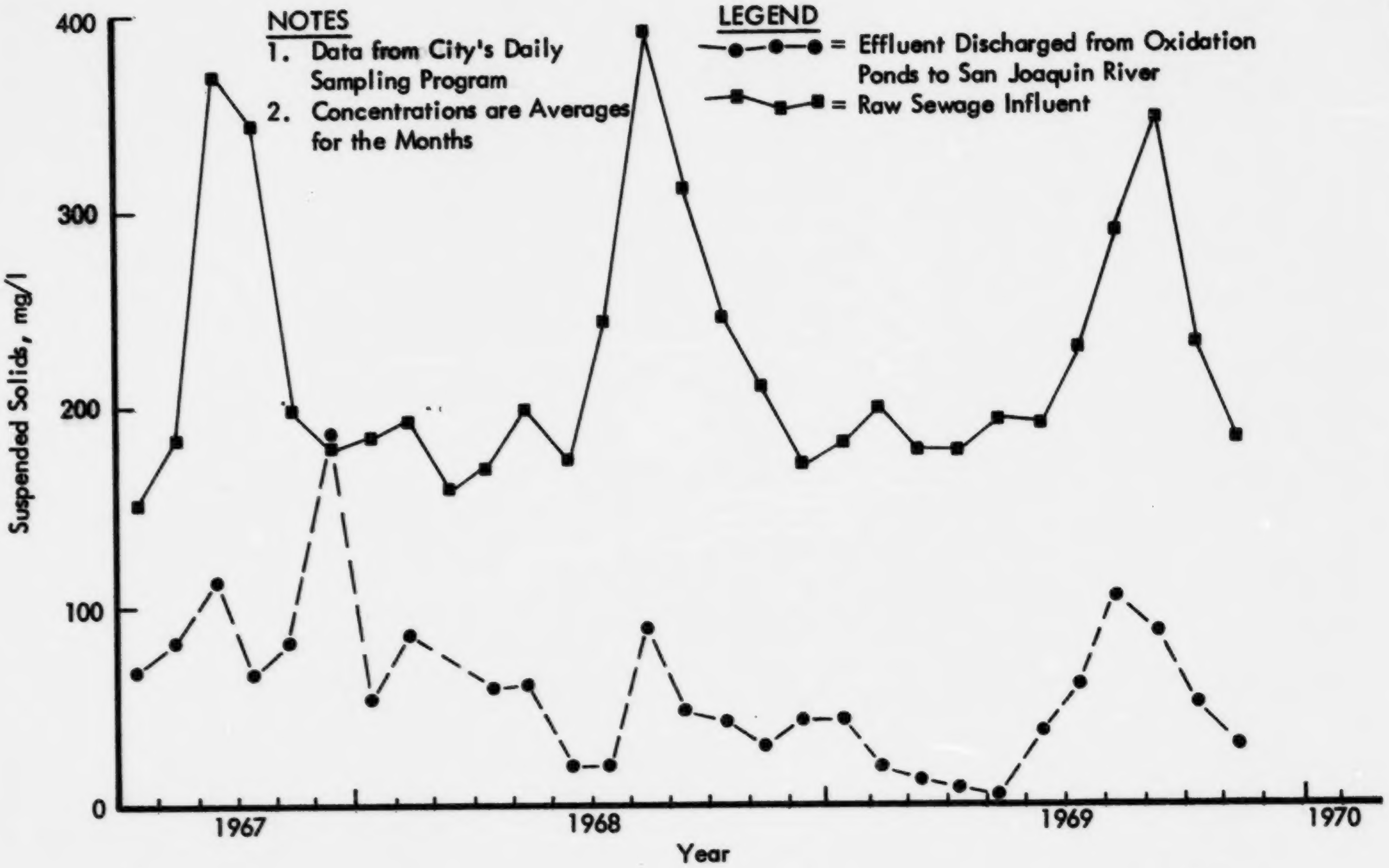
BOD
MAIN WATER QUALITY CONTROL PLANT

FIGURE IV-5



NOTES
1. Data from City's Daily Sampling Program
2. Concentrations are Averages for the Months

City of Stockton
Swift & Co. – FWPCA Project

SUSPENDED SOLIDS
MAIN WATER QUALITY CONTROL PLANT

FIGURE IV–6

TABLE IV-2

RAW SEWAGE CHARACTERISTICS[1]
MAIN WATER QUALITY CONTROL PLANT

	Daily Flow Rate (mgd)			Total Solids (mg/1)			Suspended Solids (mg/1)			Volatile Solids (mg/1)			BOD (mg/1)		
Month	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
1967															
July	15.3	18.7	10.7	917	1,112	648	159	204	120	619	769	449	278	380	200
Aug.	23.4	30.9	13.4	1,162	1,396	892	188	287	132	791	999	646	413	675	180
Sept.	31.5	37.2	16.1	1,307	2,302	874	373	1,173	186	813	1,115	537	474	600	330
Oct.	23.5	34.2	10.1	1,232	1,567	880	349	568	155	643	773	534	295	420	160
Nov.	11.6	18.1	8.2	1,096	1,322	934	204	274	156	699	808	483	348	520	180
Dec.	9.5	14.7	4.2	1,025	1,310	812	184	268	134	698	820	540	287	475	220
1968															
Jan.	11.3	27.6	8.5	1,119	3,252	708	189	287	134	798	3,120	402	273	440	100
Feb.	9.4	15.1	6.7	1,088	1,528	888	199	345	146	714	1,054	616	308	415	160
March	11.2	19.0	7.5	966	1,176	666	164	210	62	651	864	446	296	430	180
April	15.0	19.7	10.3	999	1,555	784	176	260	142	680	1,227	502	280	390	190
May	15.5	18.3	11.0	1,034	1,354	685	203	225	93	692	1,006	376	257	540	160
June	15.4	18.6	12.2	1,011	1,133	911	179	233	152	674	764	540	292	360	195

TABLE IV-2 (Continued)

RAW SEWAGE CHARACTERISTICS[1]
MAIN WATER QUALITY CONTROL PLANT

	Daily Flow Rate (mgd)			Total Solids (mg/1)			Suspended Solids (mg/1)			Volatile Solids (mg/1)			BOD (mg/1)		
Month	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
1968															
July	17.8	31.0	8.9	1,033	1,229	838	247	298	127	697	850	535	319	525	160
Aug.	33.0	37.8	20.8	1,239	1,575	940	393	460	183	835	1,061	598	546	750	270
Sept.	32.3	35.8	15.2	1,195	1,402	970	317	477	237	773	948	572	353	565	260
Oct.	22.9	35.4	11.8	1,106	1,410	850	251	408	159	746	1,000	504	311	450	220
Nov.	12.5	19.5	8.7	1,072	1,196	900	215	269	141	737	892	628	355	440	205
Dec.	12.8	20.0	9.7	944	1,156	560	179	254	124	622	924	312	283	460	120
1969															
Jan.	14.2	23.0	9.1	1,006	1,500	702	186	539	32	888	1,132	462	286	480	125
Feb.	14.4	27.2	9.4	983	1,420	660	203	414	123	706	1,060	524	245	380	160
March	12.2	14.2	10.2	1,010	1,326	802	182	256	124	734	1,028	558	283	385	200
April	15.4	18.6	10.8	950	1,104	752	182	244	132	660	842	502	260	320	205
May	16.9	19.6	12.0	1,003	1,364	612	199	423	136	577	1,190	108	283	400	160
June	15.7	18.6	12.3	1,050	1,264	888	197	347	103	669	802	549	282	420	200

TABLE IV-2 (Continued)

RAW SEWAGE CHARACTERISTICS[1]
MAIN WATER QUALITY CONTROL PLANT

	Daily Flow Rate (mgd)			Total Solids (mg/1)			Suspended Solids (mg/1)			Volatile Solids (mg/1)			BOD (mg/1)		
Month	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
1969															
July	20.2	29.8	10.7	1,051	1,502	774	236	384	118	719	1,080	440	404	705	230
Aug.	30.3	37.1	15.3	1,162	1,387	831	294	420	186	784	1,023	548	443	750	230
Sept.	32.0	39.1	17.5	1,286	1,546	750	353	656	213	830	1,146	417	408	690	240
Oct.	16.5	24.8	9.7	1,150	1,542	770	238	371	139	752	932	491	277	435	150
Nov.	12.1	14.8	7.7	1,035	1,244	838	189	243	121	693	550	511	310	400	205
Dec.	14.9	20.8	10.8	1,004	1,434	554	192	273	130	672	960	304	271	460	160
1970															
Jan.	15.4	29.4	10.6	937	1,280	630	187	307	133	612	860	394	230	340	132
Feb.	13.8	19.6	9.8	1,064	1,206	804	199	288	153	726	932	546	284	380	205

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[1] From City's flow charts and daily sampling and analyis.

TABLE IV-3

EFFLUENT CHARACTERISTICS, mg/1 [1]
MAIN WATER QUALITY CONTROL PLANT

	Total Solids			Suspended Solids			Volatile Solids			BOD			Nitrate (NO_3)			Nitrite (NO_2)			Ammonia (NH_3)		
Month	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
1967																					
July	—	—	—	71	128	17	—	—	—	13	32	6	1.0	3.0	0.4	0.7	2.0	Tr	6.2	11.8	2.3
Aug.	756	763	749	84	129	35	—	—	—	13	27	6	0.5	0.7	0.3	Tr	Tr	Tr	0.5	1.4	0
Sept.	838	895	765	115	151	71	—	—	—	33	62	12	0.4	0.6	0.2	Tr	Tr	Tr	1.5	4.8	0.4
Oct.	—	—	—	67	97	35	—	—	—	15	32	8	—	—	—	—	—	—	2.8	3.1	2.2
Nov.	—	—	—	93	365	29	—	—	—	36	68	18	—	—	—	—	—	—	—	—	—
Dec.	—	—	—	191	717	27	—	—	—	—	—	—	—	—	—	—	—	—	9.9	10.5	9.4
1968																					
Jan.	—	—	—	57	231	23	—	—	—	71	125	30	—	—	—	—	—	—	9.6	12.0	7.1
Feb.	—	—	—	88	137	43	—	—	—	51	60	31	—	—	—	—	—	—	—	—	—
March	—	—	—	—	—	—	—	—	—	56	102	10	—	—	—	—	—	—	—	—	—
April	—	—	—	61	91	31	—	—	—	15	30	7	—	—	—	—	—	—	—	—	—
May	—	—	—	64	109	39	—	—	—	13	24	4	0.6	0.9	0.3	0.2	0.3	0.2	4.0	4.9	3.1
June	812	846	792	20	34	12	593	618	572	20	29	9	0.8	1.0	0.7	0.1	0.1	Tr	7.0	9.4	2.5
July	781	819	754	21	52	7	576	598	560	10	21	5	0.5	0.6	0.4	0.1	0.2	Tr	5.3	8.4	1.8
Aug.	740	749	728	96	163	26	580	600	550	2	2	1	—	—	—	—	—	—	2.6	4.2	0
Sept.	801	831	788	51	114	25	—	—	—	59	93	26	0.3	0.4	0.2	Tr	Tr	Tr	6.9	10.5	5.6

TABLE IV-3 (Continued)

EFFLUENT CHARACTERISTICS, mg/1
MAIN WATER QUALITY CONTROL PLANT

	Total Solids			Suspended Solids			Volatile Solids			BOD			Nitrate (NO_3)			Nitrite (NO_2)			Ammonia (NH_3)		
Month	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
1968																					
Oct.	807	942	652	45	87	22	556	603	499	32	52	14	0.3	0.8	0.1	Tr	Tr	Tr	4.7	6.4	3.1
Nov.	744	805	706	33	65	22	517	546	470	3	5	1	0.1	0.1	Tr	—	—	—	6.1	6.6	5.6
Dec.	—	—	—	46	124	22	—	—	—	12	26	5	—	—	—	—	—	—	—	—	—
1969																					
Jan.	—	—	—	43	80	20	—	—	—	14	26	6	0.5	1.0	0.3	0.4	0.9	0.1	6.7	7.7	5.6
Feb.	—	—	—	22	56	5	—	—	—	6	10	3	0.4	0.5	0.3	Tr	0.1	Tr	8.5	9.4	7.0
March	—	—	—	17	26	10	—	—	—	4	12	2	0.4	0.7	0.3	Tr	0.1	Tr	12.7	15.4	11.2
April	—	—	—	13	24	5	—	—	—	3	5	2	0.5	0.8	0.3	2.7	3.6	0.6	16.1	18.2	14.7
May	—	—	—	9	21	2	—	—	—	3	6	2	0.6	1.2	0.6	Tr	0.1	Tr	14.4	15.5	12.7
June	—	—	—	40	73	8	—	—	—	5	8	3	0.6	0.9	0.1	0.1	0.1	Tr	4.4	7.3	3.1
July	—	—	—	62	91	32	—	—	—	9	20	2	0.7	1.5	0.2	0.1	0.2	Tr	0.9	4.2	0
Aug.	—	—	—	107	160	4	—	—	—	19	29	4	—	—	—	—	—	—	—	—	—
Sept.	—	—	—	89	159	29	—	—	—	24	34	13	Tr	0.1	Tr	Tr	0.1	Tr	6.5	10.2	4.2
Oct.	—	—	—	54	185	23	—	—	—	11	23	5	0.5	0.7	0.3	Tr	0.1	Tr	7.9	9.1	6.0
Nov.	—	—	—	32	53	18	—	—	—	9	15	6	0.8	1.5	0.5	0.2	0.2	0.1	8.1	8.8	7.4
Dec.	714	736	695	34	60	16	379	399	359	16	30	4	1.2	1.9	0.2	0.2	0.2	0.1	8.7	9.4	8.4

TABLE IV-3 (Continued)

EFFLUENT CHARACTERISTICS, mg/1
MAIN WATER QUALITY CONTROL PLANT

	Total Solids			Suspended Solids			Volatile Solids			BOD			Nitrate (NO_3)			Nitrite (NO_2)			Ammonia (NH_3)		
Month	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min	avg	max	min
1970																					
Jan.	--	--	--	64	217	13	--	--	--	27	42	12	--	--	--	--	--	--	--	--	--
Feb.	638	666	599	11	20	4	368	422	307	4	6	3	1.8	2.4	1.0	0.2	0.3	0.2	8.3	9.8	5.6

Footnotes: 1 From City's daily sampling and analyses collection costs attributed to the Main Water Quality Plant, the total 1969-70 treatment cost was estimated to be $587,000. With the addition of new facilities proposed for the five-year program, the total Main Water Quality Plant operation and maintenance costs were estimated to be $814,000 per year.

C. WATER QUALITY EFFECTS ON THE SAN JOAQUIN RIVER

Water quality in the San Joaquin River at Stockton is affected by waste discharges and irrigation return flows from all tributary sources in the San Joaquin Valley, the characteristics of the river and delta, the upstream storage and diversions from the river for agricultural purposes, and tidal influences. Among the many waste discharges to the river is effluent from the Main Water Quality Plant. As stated previously, the Regional Water Quality Control Board has established water quality objectives and waste discharge requirements for the San Joaquin River at Stockton. (See Appendix A.) The constituents which have the greatest effect on treatment plant operations are dissolved oxygen, total nitrogen, and total dissolved solids. The requirements state that the discharges from the plant shall not cause the dissolved oxygen content of the receiving waters to fall below 5 mg/l; nor cause the total nitrogen content to exceed 3 mg/l; nor cause the mean monthly total dissolved solids to exceed 500 mg/l.

Although BOD removal efficiencies normally range from 90 to 99 percent, consistently higher removal efficiencies must be achieved to meet the dissolved oxygen requirement. These can be achieved by construction of additional treatment facilities and/or reduction of the BOD loading in the raw sewage.

Studies that are being performed may indicate the nitrogen and total dissolved solid limitations can be met without tertiary treatment and/or demineralization. These studies are theoretical in nature and involve mathematical modeling to define the interrelationships of the San Joaquin River, delta, tidal prism, and waste discharges.

D. SEWAGE SAMPLING

A sampling program was designed to determine the characteristics and to estimate the volumes of sewage within the Main Water Quality Plant. The program was designed to include normal operating analysis. Additional comprehensive data was collected during three separate month-long periods which represented the special study to define the three basic seasonal conditions.

A statistically significant number of samples were taken and analyzed during the Spring, Summer, and Winter Sample Periods. Figures IV-1 and IV-2 show the sampling station locations. These locations were at the pretreatment (spring sampling only) works, primary sedimentation tanks, trickling filters, secondary sedimentation tanks, and oxidation ponds. The sampling and analysis performed especially for this feasibility study were grab samples taken at selected times. The special Main Water Quality Plant samples were collected at the same time as the Swift and Southern Industrial Sanitary Trunk samples. They were collected with due allowance for flows and the time within the trunk sewer and Main Water Quality Plant works. The samples were routinely collected and composited throughout the day for the various Main Water Quality Plant stations. The results of each day's analysis were averaged over a month's duration. The average values are summarized in Tables IV-2 and IV-3.

Grab samples were collected and analyzed by City personnel in their laboratory at the Plant. Critical analyses were done as soon as possible for characteristics that changed significantly with time. For those characteristics which do not change with time, a portion of each sample was composited and analyzed at the end of each sampling period. The flow rates of raw sewage entering the plant were recorded. It was not practical to measure individual flows within the plant processing units or the plant effluent discharged into the San Joaquin River.

Average, maximum, and minumum plant wastewater characteristics during the month-long Spring Sampling Period are summarized in Tables II-8 and II-9, respectively. Similar data from the Summer and Winter Sampling Periods are presented in Tables II-11 and II-12, and Tables II-14 and II-15, respectively.

Results from the special surveys and from the normal plant control samples were generally similar, with some variations due to peak or minimal conditions. The special surveys and analysis included elements which were not routinely tested but which were important for new sewage treatment facility planning and water quality control. The special surveys emphasized were nutrient and chemical composition determinations. Routine analysis emphasized BOD, suspended solids, and other common operational parameters.

E. CENTRAL TREATMENT OF SWIFT WASTEWATER

One of the principal benefits for upstream activated sludge treatment of meat packing waste would be the reduced load on the Main Water Quality Plant, thereby providing additional capacity for treatment of other wastewaters and reducing the need for expanding future facilities.

Effluent from an upstream activated sludge plant would also provide the Main Water Quality Plant influent sludge with aerobic bacterial "seed" organisms which could pre-condition the raw sewage influent and improve the Main Water Quality Plant's biological efficiencies.

Pretreatment of Swift waste by activated sludge will also remove some nitrogen and phosphates. Due to the high nutrient concentrations in Swift waste, this could be the deciding factor on whether or not denitrification facilities may be required for Stockton in the future.

The effect of Swift wastewaters on the Main Water Quality Plant is illustrated in Tables IV-4 and IV-5. Table IV-4 indicates the average characteristics of plant influent with and without Swift wastewater during the non-canning season and during the canning season. Table IV-5 shows the percentage of the total plant flow from Swift.

Wastewater discharged from Swift contributed approximately 7 percent of the City's total hydraulic flow on an average day during the dry season when canneries were not operating. When the canneries were operating, Swift wastewater discharged approximately 3 percent of the total flow.

During the non-canning season, Swift contributed approximately 18 percent of the total BOD Main Water Quality Plant loading (based on 1967-68 flow records). During the canning season, BOD from Swift was about 4 percent of the total loading. Swift contributed suspended solids during the non-canning season equal to approximately 16 percent of the total. During the canning season, Swift contributed about 3 percent of the total suspended solids. Defined as a percentage of the projected five-year flow and loading, the BOD from Swift during non-canning season constitutes 52 percent of the expected increased load, and during the canning season, 16 percent of the anticipated increased load.

BOD was the parameter used to compare the costs of treatment of Swift wastewaters with treatment of the total flow at the Main Water Quality Plant. BOD was used because it is one of the primary criteria for designing and sizing biochemical treatment works, and also since nutrient loadings and removals generally parallel BOD removal. The projected 1973-74 wastewater discharges were used as the basis for computing both the existing flows and facilities loading and increased flows and future facilities loading. The proportion of BOD discharged from the Swift plant to the total BOD received at the Main Water Quality Plant was evaluated for the year-round operations. During the 9-month non-canning season the BOD load from Swift was about 18 percent of the total plant load. During the 3-month canning season, the BOD load from Swift was about 5 percent of the total load. The weighted year-round average was calculated to be 11 percent of the total BOD Main Water Quality Plant loading.

Based on general curves relating the cost of treatment works, construction, and operation and maintenance to waste load and site conditions, a sizing factor of 0.6 was applied to the previously computed 11 percent. Thus, it was estimated that 7 percent of costs for basic replacement of the Main Water Quality Plant capacity, and plant operation expense, could be attributed to treatment of Swift industrial waste.

TABLE IV-4

AVERAGE CHARACTERISTICS OF RAW SEWAGE, MAIN WATER QUALITY CONTROL PLANT

Description	Present Flows			Projected 4 5-yr Flows
	Without Swift & Co. Wastewater 1	With Swift & Co. Wastewater 2		
		1-Shift Operation	2-Shift 3 Operation	
Flow, mgd		(5)		
During noncanning season				
Average dry weather flow (ADWF)	14	15	16	23
Peak storm rate	43	44	45	60
During canning season				
Maximum working day	38	40	40	67
Maximum working week (6 days)	35	36	37	61
Maximum month	33	34	34	58
Peak rate	43	45	45	75
Biochemical oxygen demand, BOD		(5)		
During noncanning season				
Concentration, mg/1	280	330	370	
Total load, 1,000 lb/day	33	39	44	54
During canning season				
Maximum working day				
Concentration, mg/1	690	730	750	
Total load, 1,000 lb/day	219	232	236	306
Maximum working week (6 days)				
Concentration, mg/1	640	670	690	
Total load, 1,000 lb/day	185	194	198	260
Maximum month				
Concentration, mg/1	610	630	650	
Total load, 1,000 lb/day	168	174	179	236

TABLE IV-4 (Cont.)

AVERAGE CHARACTERISTICS OF RAW SEWAGE
MAIN WATER QUALITY CONTROL PLANT

Description	Present Flows			Projected[4] 5-yr Flows
	Without Swift & Co. Wastewater[1]	With Swift & Co. Wastewater[2]		
		1-Shift Operation	2-Shift[3] Operation	
Suspended solids, SS		(6)		
During noncanning season				
Concentration, mg/l	160	185[5]	200	
Total load, 1,000 lb/day	19	22	24	31
During canning season				
Maximum working day				
Concentration, mg/l	490	510	520	
Total load, 1,000 lb/day	155	161	164	217
Maximum working week (6 days)				
Concentration, mg/l	450	470	480	
Total load, 1,000 lb/day	131	136	138	184
Maximum month				
Concentration, mg/l	410	420	430	
Total load, 1,000 lb/day	119	123	125	167

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[1] 1967-68 data from Brown and Caldwell, Consulting Engineers report entitled "City of Stockton Main Water Quality Control Plant, 1969 Enlargement and Modification Study", dated May 1969.

[2] Same as 1 with addition of Swift and Company discharges.

[3] Based on 5 days/week operation, 1.5 mgd, 1200 ppm.

[4] From Brown and Caldwell, Consulting Engineers report entitled "City of Stockton Main Water Quality Control Plant, 1969 Enlargement and Modification Study", dated May 1969.

[5] Swift and Company discharges based on monthly sewer service charge records from January to June 1969.

Based on demonstration program sampling in June and September 1969.

TABLE IV-5

PROPORTION OF SWIFT AND COMPANY FLOW TO TOTAL PLANT FLOW

Description	Existing Swift & Co. Flow as % of 1967-68 Flow	Planned Swift & Co. Flow	
		As % of 5-year Increased Flow	As % of Projected 1973-74 Flow
Flow quantity			
During noncanning season			
Average dry weather flow	7	17	7
Peak storm rate	2	12	3
During canning season	3	4	3
Weighted for year-round condition [2]	5	12	5
Biochemical oxygen demand, BOD			
During noncanning season	18	52	20
During canning season	4	16	5
Weighted for year-round condition [2]	9	34	11
Suspended solids, SS			
During noncanning season	16	42	16
During canning season	3	13	3
Weighted for year-round condition [2]	7	24	8

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[1] Based on Table IV-4

[2] Assuming noncanning average dry weather flow 9 months/yr and canning season flow 3 months/yr.

V. LABORATORY AND FIELD TESTS

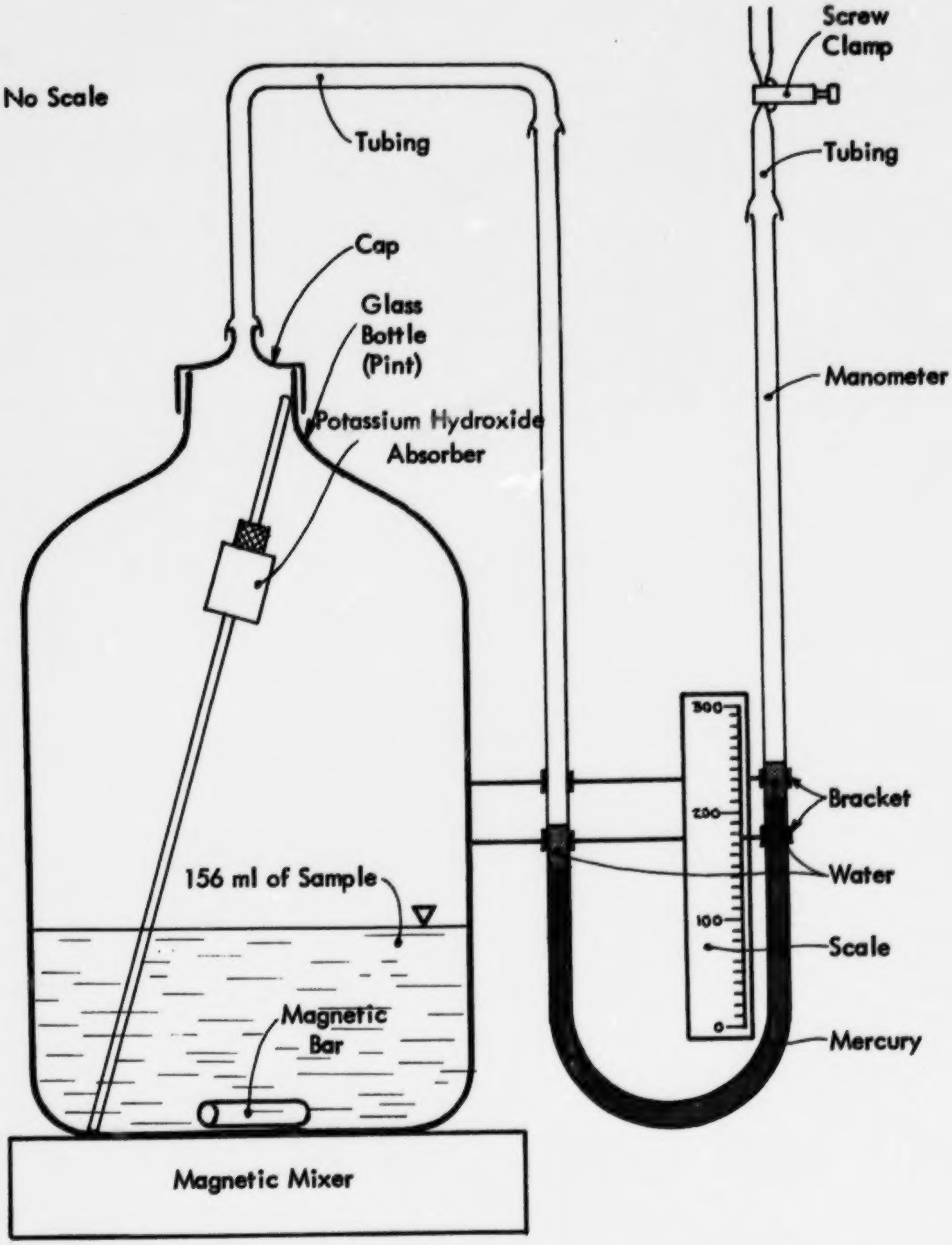
A. OXYGEN UPTAKE

Three sets of oxygen uptake tests were conducted in the project engineer's laboratory. These tests replicated sewage flow in the Southern Industrial Trunk. On both the first and second test sets, three bench scale runs were made on Swift wastewater to measure the quantity of oxygen needed to maintain an aerobic environment and also to directly measure the characteristics of the Swift waste for absorption of oxygen in the activated sludge treatment process.

On the first two sets of tests, samples were collected in 5 gallon plastic containers from the Parshall flume at Swift, immediately upstream of the City sewer. When collected, the sewage temperature ranged from 93° to 95°F. Immediately after collection, the sewage samples were packed in dry ice and shipped to the project engineer's laboratory where they were unfrozen and stored over approximately four weeks at a temperature of about 35°F to arrest microbial activity which could change the organic composition of the samples. Before the samples were used for the oxygen uptake tests, a 2-liter portion of the sample was taken from cold storage and warmed to 93°F, the temperature at which Swift wastewater was discharged. The sample was aerated briefly to raise the dissolved oxygen concentration to 4 mg/l. Facultative bacteria isolated from activated sludge were added to the sample as a seed to simulate bacteria in the sewers. Approximately 5×10^4 bacteria/ml of sample were added. The seeded sewage was then poured into 500 ml test jars.

In the first set of tests only two conditions were simulated: 1) unstirred to replicate laminar or smooth flow in the sewer; and 2) stirred, to replicate aeration within the sewer, either by natural turbulence such as bends and junctions or by diffusion of air. Stirring was by means of a magnetic mixing apparatus. Potassium hydroxide absorption and a manometer were used to measure oxygen consumption. The test apparatus is shown schematically in Figure V-1. During the first test series run, oxygen consumption was measured every half hour over a four-hour period. For the second and third test runs, oxygen consumption was measured every hour over a six-hour period. Based on the Southern Industrial Trunk flowing half full, wastewater would be detained in the sewer for approximately five hours. At low flow conditions, wastewater would remain in the sewer for six to eight hours. In all three runs, ambient temperatures of 95°F were maintained to correspond to the maximum temperature of waste discharged from the Swift plant.

Figure V-2 illustrates the oxygen consumption for both the stirred and unstirred test conditions. For the unstirred test condition the oxygen uptake ranged from 5 to 10 mg/l per hour. For the stirred test conditions, the oxygen uptake ranged from 15 to 20 mg/l per hour.

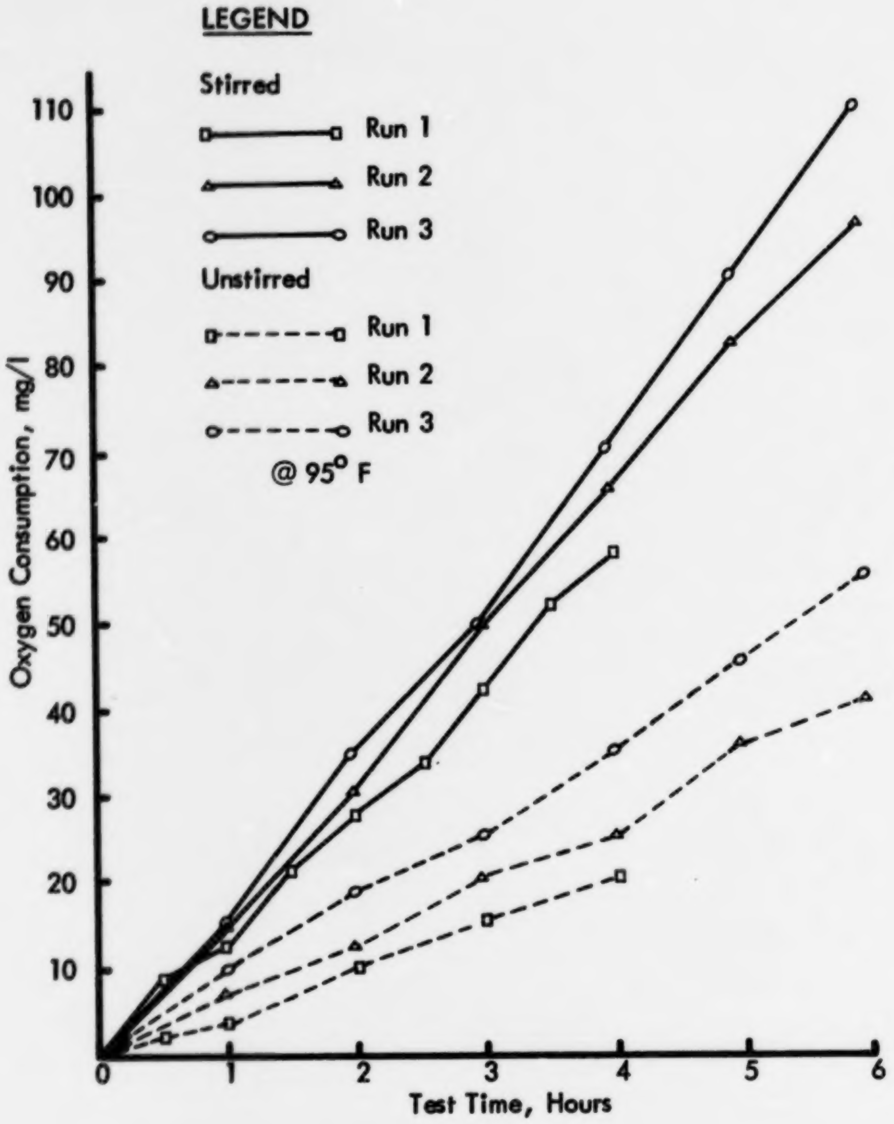

No Scale

Screw Clamp
Tubing
Tubing
Cap
Glass Bottle (Pint)
Potassium Hydroxide Absorber
Manometer
300
200
100
0
Bracket
Water
Scale
Mercury
156 ml of Sample
Magnetic Bar
Magnetic Mixer

City of Stockton
Swift & Co. - FWPCA Project

BOD OXYGEN
UPTAKE APPARATUS

FIGURE V-1



City of Stockton
Swift & Co. - FWPCA Project

OXYGEN UPTAKE,
TEST 1

FIGURE V-2

For the second set of tests three conditions were simulated: 1) unstirred surface aeration; 2) slow mix and rapid mix; and 3) some subsurface aeration. The Figure V-1 apparatus was used to simulate the aeration conditions. For the rapid mix, the magnetic stirrer was operated with a stirring speed control that could be set at up to 700 rpm. Again the tests were run at 93°F. As shown on Figure V-3, the oxygen consumption for each of three test runs was almost identical. Oxygen uptake for the unstirred, slow mixing (350 rpm) and rapid mix (700 rpm), conditions averaged 12, 18, and 30 mg/l per hour, respectively.

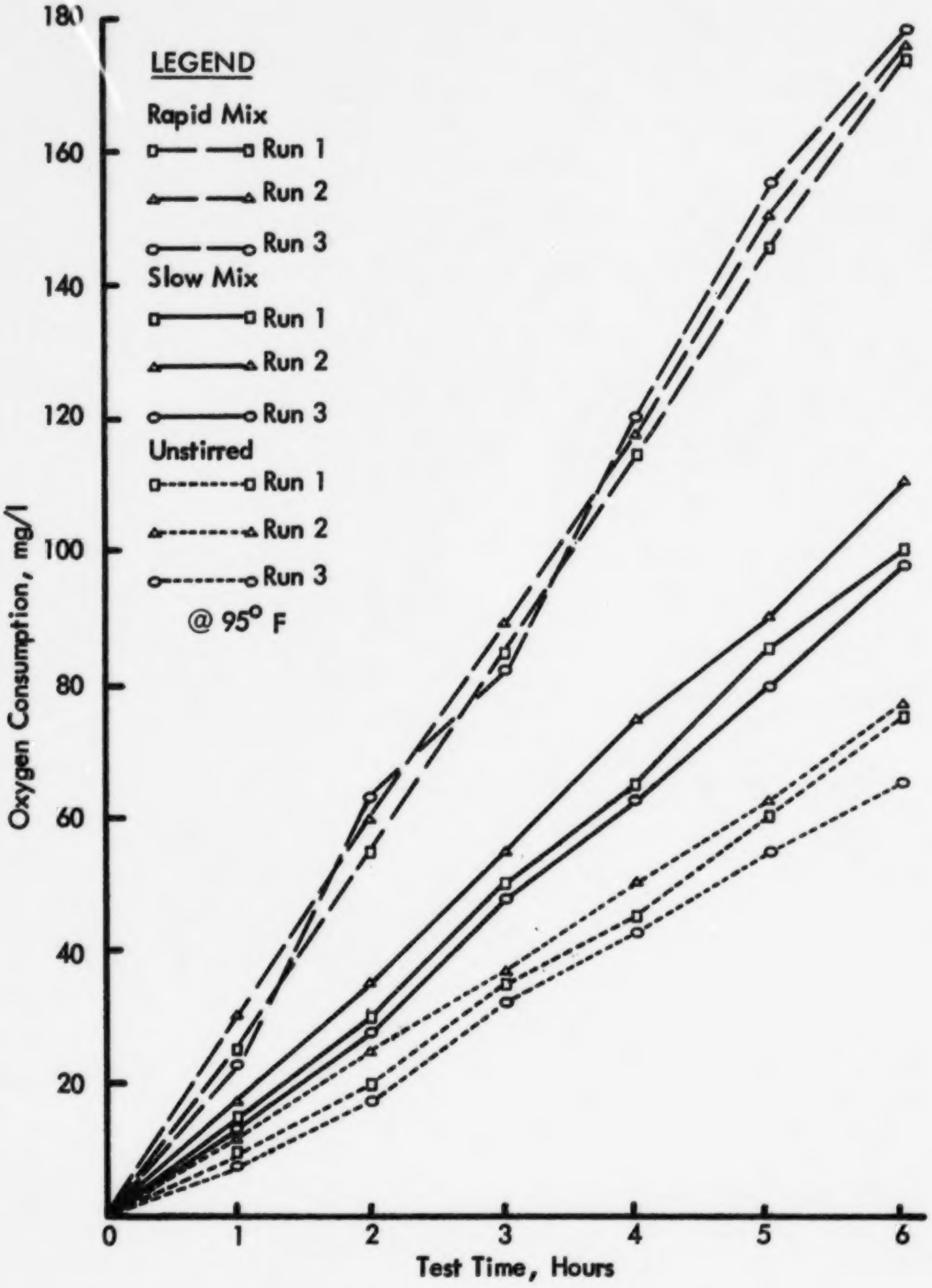
For each of these test runs dissolved oxygen was measured prior to stirring, and following stirring. Initial dissolved oxygen concentrations were about 4.0 mg/l, and, following mixing, ranged from 0 to 0.5 mg/l.

To estimate the effect on the Swift waste of oxygen demand by the cold storage, a third set of tests was run using a freshly collected sample (1 day of cold storage) and a four-week-old sample (the sample used for the second test set). Basically, the test also measured biochemical oxygen demand. Seed was not added to the samples, nor were the samples aerated prior to starting the test. Two conditions were tested: stirred and unstirred. The test was carried out for 5 days, and the daily results are plotted in Figure V-4. The BOD for the unstirred condition was 340 mg/l for the fresh sample and 80 mg/l for the four-week-old cold storage sample. For the stirred condition, BOD of 485 mg/l was measured for the fresh sample, compared to 220 mg/l for the old sample. It is interesting to note in Figure V-4 that oxygen demand for the first 1 to 1-1/2 days was approximately the same for the fresh and old sample; thereafter the oxygen demand differed dramatically between the two samples. The difference in results was attributed in part to the congealing of grease and protein matter on the surface of the storage container, since only the liquid portion of the sample was used for the test.

These controlled tests indicated that actual in-sewer oxygen uptake could be up to twice the rates measured in the first and second test sets. Conversely, some of the oxygen demand of waste in the Southern Industrial Trunk is satisfied by in-line reaeration. As described in Chapter III, the trunk sewer gases were high in oxygen. The effect on oxygen consumption of bacterial seed is illustrated by comparison of Figures V-2 and V-3 with Figure V-4. The test employing a stored sample that was seeded showed oxygen consumption of about 100 mg/l at 95° over a six-hour period; without bacterial seeding, the oxygen consumption for the same sample was about 25 mg/l for the first six hours and did not reach 100 mg/l oxygen consumption until after 34 hours.

B. U-TUBE AERATION

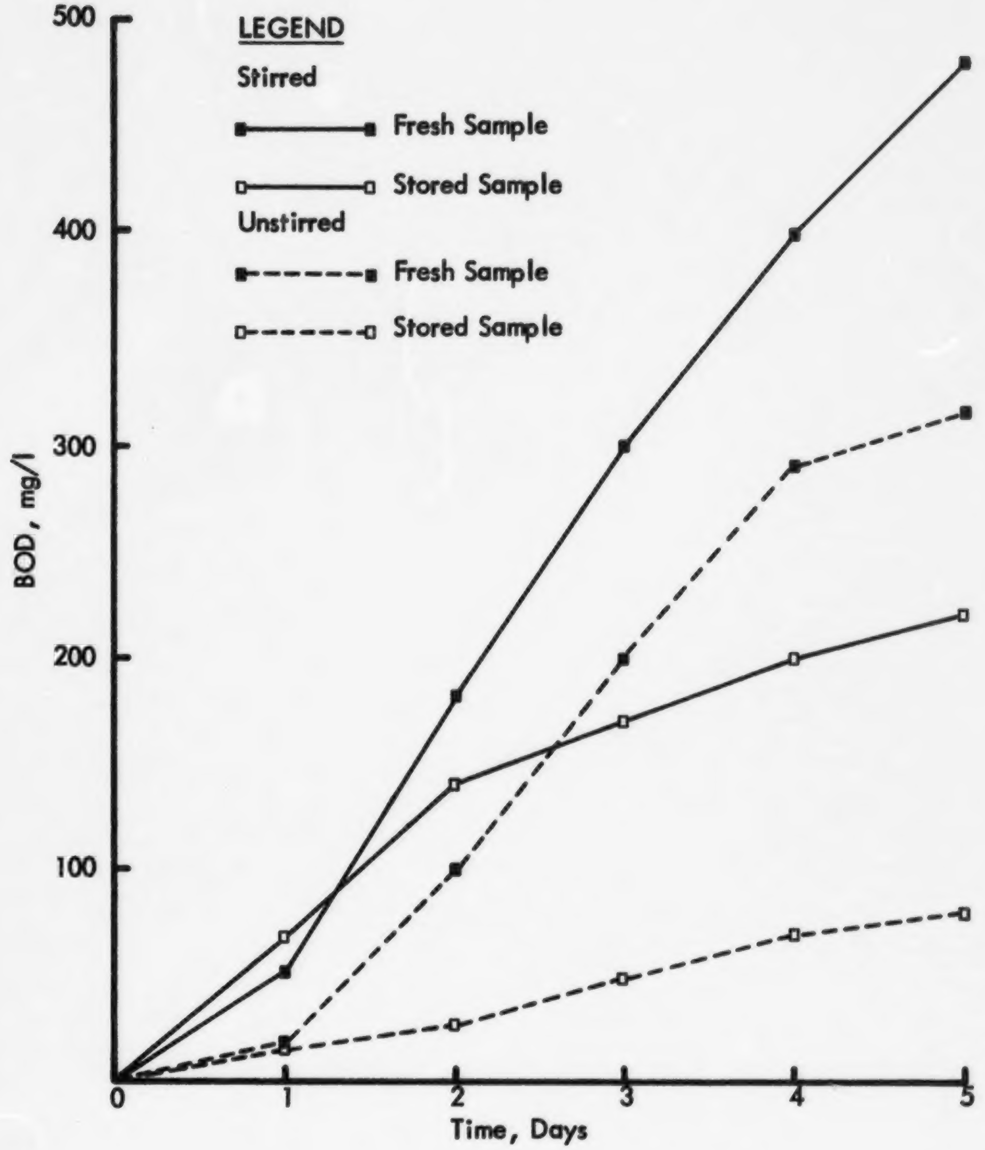
Bench scale tests were conducted to simulate U-Tube aeration. Raw wastewater from the Swift plant effluent from the previously-described (Section V-A) tests was used. The U-Tube test apparatus is illustrated by Figure V-5. Generally, the test replicated



City of Stockton
Swift & Co. - FWPCA Project

OXYGEN UPTAKE,
TEST 2

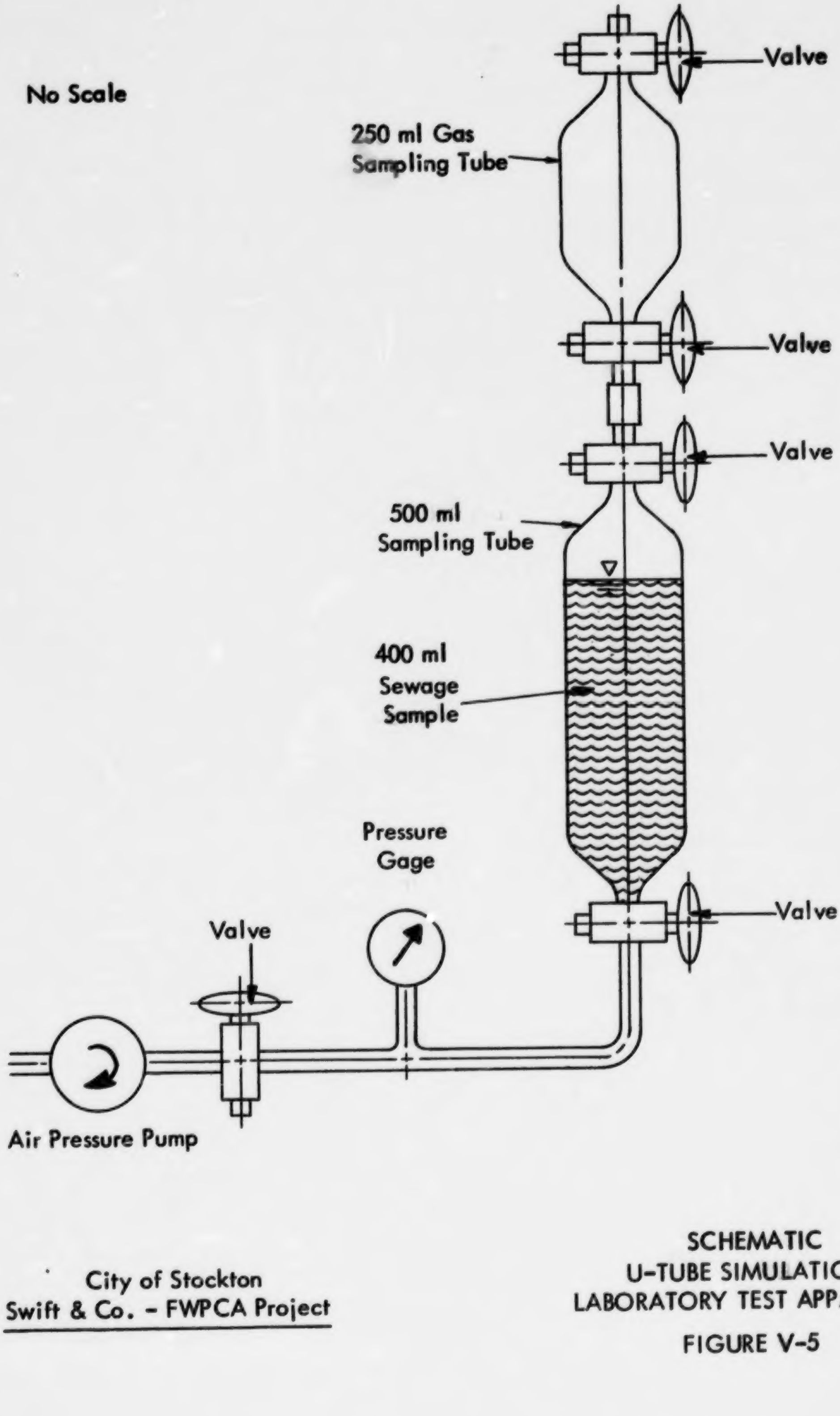
FIGURE V-3



City of Stockton
Swift & Co. - FWPCA Project

EFFECT OF STIRRING
BOD CONTROL, TEST 3

FIGURE V-4


No Scale
Valve
250 ml Gas Sampling Tube
Valve
Valve
500 ml Sampling Tube
400 ml Sewage Sample
Pressure Gage
Valve
Valve
Air Pressure Pump

City of Stockton
Swift & Co. - FWPCA Project

SCHEMATIC
U-TUBE SIMULATION
LABORATORY TEST APPARATUS

FIGURE V-5

aeration (oxygen) of samples under pressure. Specifically, for each test run, a 400 ml waste sample was poured into a 500 ml volume pressure sampling vessel. With the sampling vessel in a vertical position and the upper valve closed, compressed air was forced into the bottom of the vessel and bubbled through the waste sample until the pressure reached the designated levels of 10 and 20 psi. After forcing approximately 200 ml of air at 80°F and sea level pressure through the sample, the bottom valve on the sampling tube was closed, and the pressurized waste was agitated by shaking vigorously for thirty seconds; the shaking replicated velocity flow residence time in the U-Tube. Ambient and waste temperatures were kept at 80°F. The upper valve on the 500 ml sampling tube and the lower valve on the 250 ml gas sampling tube were next opened and the gas from the former was allowed to equalize into the latter. The 250 ml gas sampling tube had previously been evacuated to a vacuum pressure of 22-in. of water.

The waste was then analyzed for dissolved oxygen using the Winkler Method; hydrogen sulfide and pH were tested at various time intervals over three hours. The zero time analyses were performed immediately before aerating the waste and the one-minute analyses were performed one minute after beginning aeration. All analytical test procedures complied with Standard Methods.[1]

The results of analyses of three tests runs at 20 psi pressure are summarized in Table V-1. Dissolved oxygen content increased slightly due to the aeration, and the sulfides were oxidized. After aeration and contact time, the dissolved oxygen was consumed and the sulfides increased in one sample. The dissolved oxygen content did not increase as much as expected. This was attributed to either the wastewater characteristics or the limitations of the U-Tube replication by the relatively simple laboratory apparatus.

The gas from the 250 ml gas sampling tube was analyzed to determine changes in characteristics due to oxidation. As shown on Table V-2, the composition of gases used for U-Tube aeration was essentially atmospheric, indicating that U-Tube aeration had not changed the gas composition.

C. ACTIVATED SLUDGE TESTS

1. General

A Kehr activated sludge laboratory pilot plant test program was designed to supplement the findings of the FMC Corporation Kehr pilot-scale tests conducted in 1967 and 1968.[2] Initially, the FMC Corporation's final report draft to the Federal Water Pollution Control Administration was studied. Their report described their test work over a period of forty days; one run was made for 28 continuous days and a second run was made for 12

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[1] Standard Methods for the Examination of Water and Wastewater Including Bottom Sediments and Sludges, prepared and published jointly by the American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, 12th edition, New York, 1965.

[2] Cannery Waste Treatment by the Kehr Activated Sludge Process, Report R-2795, FMC Corporation, Environmental Engineering Department, Central Engineering Laboratories, prepared for the Federal Water Pollution Control Administration, June, 1969.

TABLE V-1

U-TUBE AERATION - LABORATORY SIMULATION[1]

Elapsed[2] Time, min	Swift Raw Waste[3]			Kehr Process Effluent[4]			Aerated Kehr Process Effluent[5]		
	Dissolved Oxygen, mg/1	pH	Hydrogen Sulfide mg/1	Dissolved Oxygen, mg/1	pH	Hydrogen Sulfide mg/1	Dissolved Oxygen, mg/1	pH	Hydrogen Sulfide mg/1
0	0.1	6.5	2.5	1.8	7.0	0	2.1	7.0	0
1	0.6	6.8	0.5	2.1	7.0	0	2.2	7.0	0
10	0.5	6.9	0.7	2.0	7.0	0	2.2	7.0	0
30	0.4	7.1	0.8	2.0	7.0	0	2.0	7.0	0
60	0.4	7.0	1.0	1.9	7.0	0	1.8	7.0	0
120	0.2	7.0	1.2	1.8	7.0	0	1.8	7.0	0
180	0.1	7.0	1.3	1.7	7.0	0	1.7	7.0	0

[1] Pressurized to 20 psi for 30 seconds; ambient and liquid temperature was 80°F.

[2] Zero time is immediately before U-Tube aeration.

[3] Stored at 35°F for about one month.

[4] Clarified effluent from high-rate activated sludge laboratory tests.

[5] Clarified effluent from high-rate activated sludge laboratory tests was aerated for 15 minutes by low pressure air diffusion prior to U-Tube aeration.

TABLE V-2

ANALYSIS OF GASES FROM U-TUBE AERATION TESTS

Source of Gas	Gas Composition, Percent by Volume				
	CO_2	O_2	N_2	CH_4	CO
Standard Sample[1]	8.7	15.6	69.6	2.7	3.4
From U-Tube Test on Swift Raw Effluent	0.5	21.2	78.4	0	0
From U-Tube Test on Kehr Process Effluent	0	21.9	78.1	0	0
Atmospheric	0	21.6	78.4	0	0

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[1] Composition of standard sample was reportedly 5 percent CO_2; 15 percent O_2; 70 percent N_2; 5 percent CH_4; and 5 percent CO, plus or minus 3 percent.

continuous days. FMC ran their tests on two general types of wastewater: cannery wastewaters, with BOD ranging up to 1,550 mg/l, and domestic sewage, with BOD averaging 200 mg/l.

FMC personnel who conducted their test work were contacted and they informally presented their results, operating problems, and recommendations for a full-scale Kehr process activated sludge plant for Swift. In addition, the FMC Staff visited the Swift facility and were cognizant of the specific Swift wastes. The FMC pilot-test equipment was formally requested for Swift tests, but it was dismantled and the parts had either been discarded or were being used for other purposes. It was not possible to use their pilot-scale facilities to run tests on the meat packing wastes.

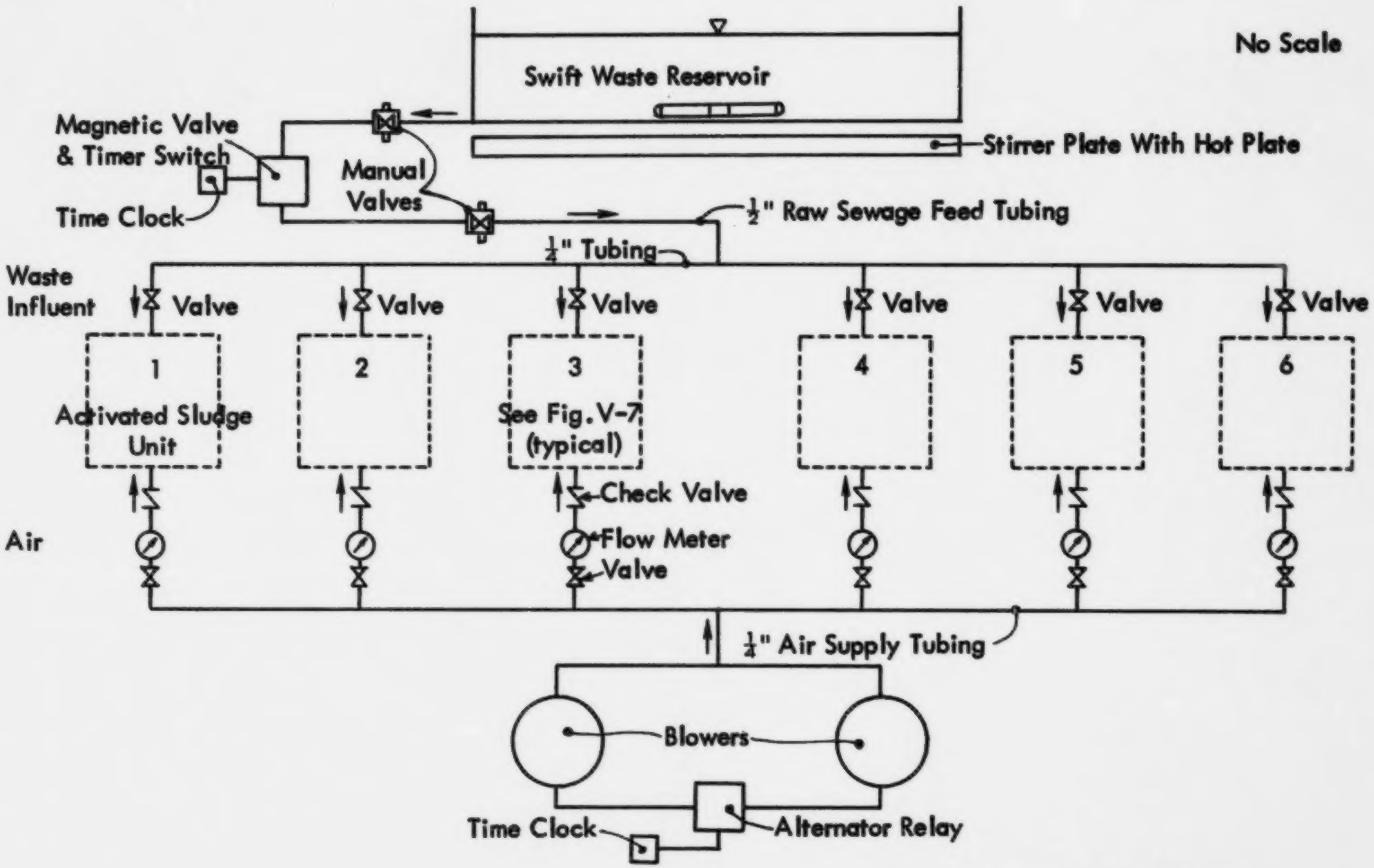
Based on the FMC test data and discussions, it was felt that further pilot-scale testing would be costly and repetitive. A more efficient program was to conduct controlled tests in the laboratory to define specific process differences due to the characteristics of the meat packing wastes compared to the cannery wastes used by FMC. The differences that were considered most important were oxygen uptake, contact time, potential foaming and scum problems, flow characteristics of the Kehr high suspended solid mixed liquor, odors, BOD removal efficiency, clarification, and return of activated sludge. Laboratory tests were designed accordingly. Funding and time limitations did not provide for construction and operation of new large-scale field-located pilot plant facilities.

2. Test Series 1

In the first series of controlled tests, six pairs of one-liter plastic containers were set up as shown on Figures V-6 and V-7. Two blowers were connected to the six small pilot plants so that continuous operation could be maintained and the blowers could be alternated. Fresh air piping was connected from the blowers to each activated sludge aeration tank. A gate valve, check valve, and flow meter were installed ahead of each activated sludge aeration tank to regulate flow into the unit.

Swift industrial waste was stored in a reservoir above the aeration and clarification tanks to provide gravity flow. By means of time clocks and a magnetically-actuated valve, flow of waste to the system was regulated. Valves were placed upstream of each aeration tank to adjust the flow individually to each tank. Figure V-7 is an enlarged view of the aeration and clarification compartments and shows the activated sludge return, overflow of treated effluent, and the excess sludge drain.

To start the tests, Los Angeles City Hyperion Plant activated sludge was concentrated and used as a seed for the laboratory treatment of the Swift wastewater. Approximately 500 ml of the sludge with a Sludge Index of 33 was placed in the test apparatus and aerated at a rate of 10 l/min for 12 hours at 92°F. Throughout the aeration period, Swift waste was added at a rate of approximately 130 ml/hr to keep the activated sludge bacteria healthy.


Swift Waste Reservoir
Stirrer Plate With Hot Plate
Magnetic Valve & Timer Switch
Manual Valves
Time Clock
½" Raw Sewage Feed Tubing
¼" Tubing
Waste Influent
Valve
1
Activated Sludge Unit
2
3
See Fig. V-7 (typical)
4
5
6
Check Valve
Air
Flow Meter
Valve
¼" Air Supply Tubing
Blowers
Time Clock
Alternator Relay

No Scale

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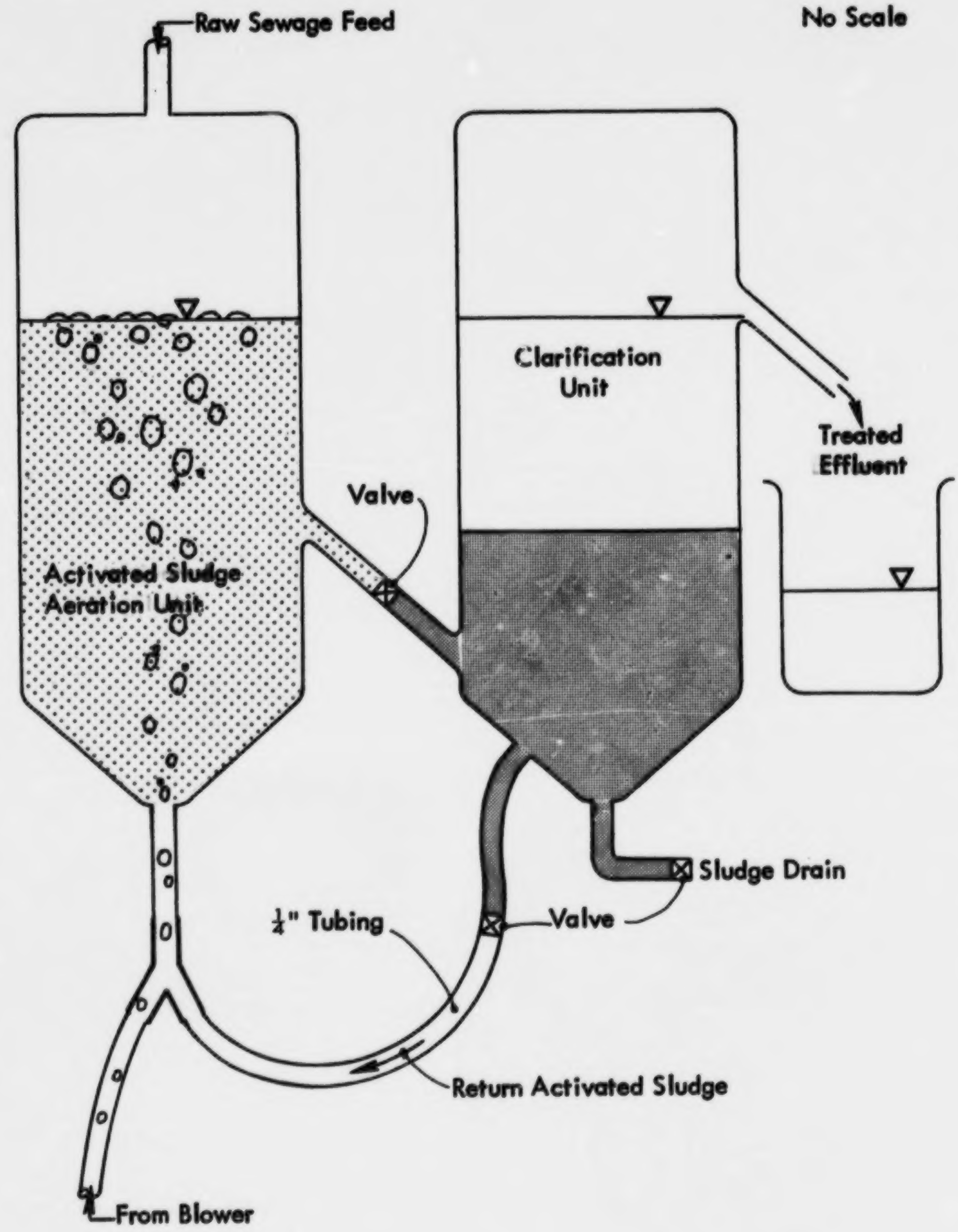
"KEHR PROCESS"
HIGH RATE ACTIVATED SLUDGE PILOT PLANT
SCHEMATIC FOR SERIES 1

FIGURE V-6


Raw Sewage Feed
No Scale
Clarification Unit
Treated Effluent
Valve
Activated Sludge Aeration Unit
Sludge Drain
¼" Tubing
Valve
Return Activated Sludge
From Blower

City of Stockton
Swift & Co. - FWPCA Project

ACTIVATED SLUDGE PILOT PLANT
AERATION AND CLARIFICATION UNITS

FIGURE V-7

The Swift wastewater sample was collected from the Parshall flume approximately 7 days before it was used for this test. The wastewater sample had been packed in dry ice and shipped from Stockton to Los Angeles; it was stored and refrigerated in the laboratory at 35°F to inhibit bacterial activity. The Swift wastewater was then warmed for the test and fed into the activated sludge pilot plants at 92°F in order to replicate field conditions. The Swift waste was stirred slowly to minimize settling and clogging. Table V-3 summarizes the test data.

The flowrate to each aeration tank was computed based on the aeration tank liquid volume and the desired aerated activated sludge detention time which ranged from two to six hours. To achieve these detention times and to minimize clogging due to small feed flows, a discharge cycle of 8 minutes off and 2 minutes on was used. Actual flowrate was calculated from the volume of effluent collected over the designated period of time as follows:

$$\text{raw waste feed rate (ml/hr)} = \frac{\text{effluent volume (ml)}}{\text{time of test (hr)}}$$

From this waste feed rate, the actual detention time was calculated as follows:

$$\text{detention time (hr)} = \frac{\text{liquid volume in activated sludge aeration tank (ml)}}{\text{raw sewage feed rate (ml/hr)}}$$

To change activated sludge detention times the feed cycle was regulated by time clocks, adjustment of the magnetic stopcock for increased or decreased flows, and also by regulation of the flow inlet valves.

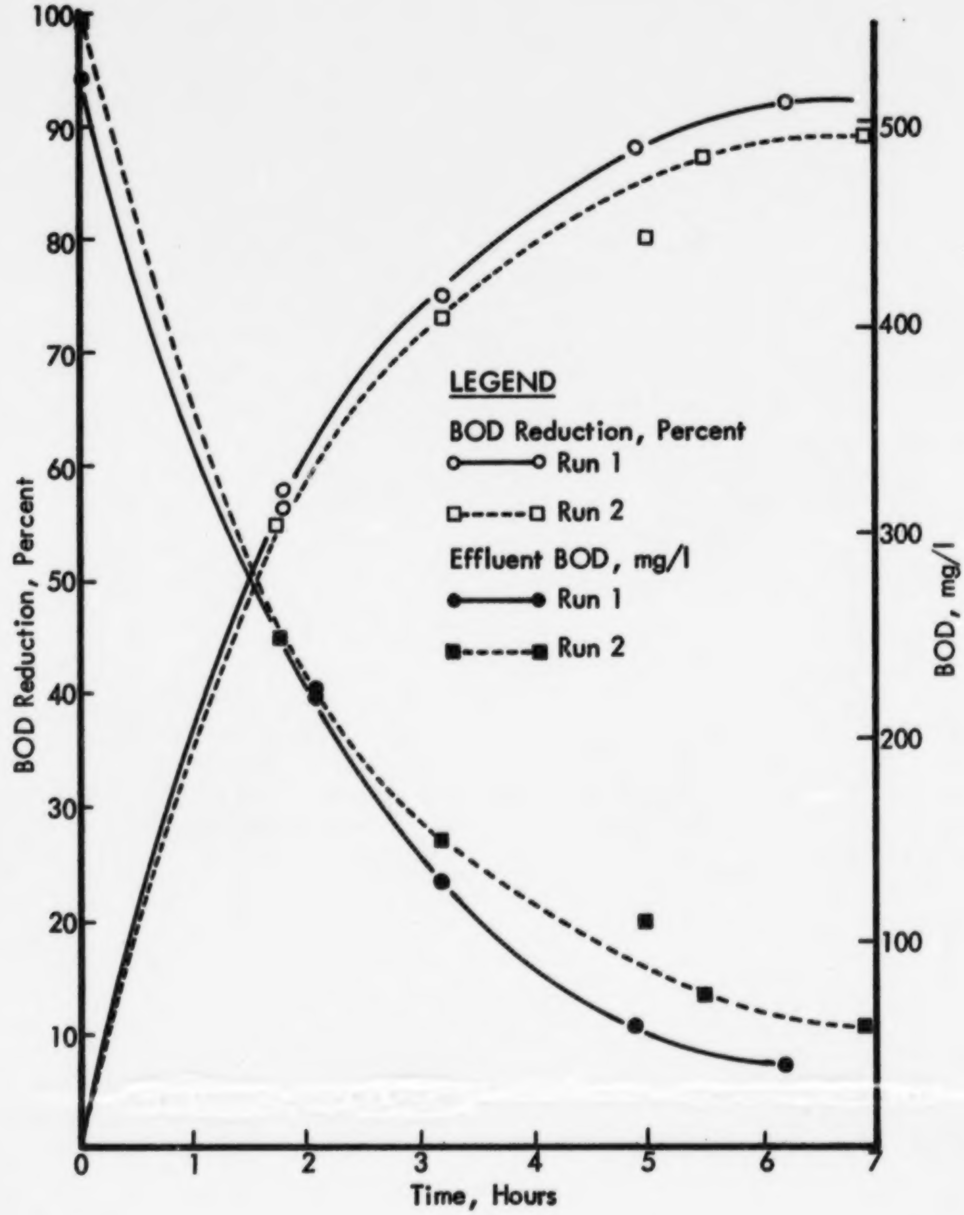
The rate of flow of return of the settled activated sludge was adjusted to minimize clogging of the tubing. Tubing was cleaned daily to reduce clogging. Basically, the return of the settled activated sludge was provided by air-lift as illustrated in Figure V-7. Excess air was added to the activated sludge aeration tanks. Effluent that overflowed the clarifier unit was collected during each test. The effluent quantity was measured, filtered to remove solids, and analyzed for BOD. The samples used for BOD determination were seeded with 0.5 ml of bacterial suspension to enhance oxygen uptake. BOD determinations were also made on unfiltered effluent and the results showed that filtration of the effluent did not significantly affect the BOD levels. In addition, a distilled water blank was tested to determine the BOD of bacteria alone at the expense of endogeneous food reserve. This endogeneous reserve BOD was subtracted from the BOD of the test effluent to determine net BOD.

A series of activated sludge Kehr process tests was run. Many of the initial tests over a period of 5 months were inconclusive because of sludge foaming or plugging problems. Results of the two best tests series which were considered to be the most representative of the system are summarized in Table V-3. In Figure V-8,

TABLE V-3

HIGH RATE ACTIVATED SLUDGE, LABORATORY TEST SERIES 1

Run No.	1					2				
Sample No.	1	2	3	4	5	1	2	3	4	5
Criteria										
Detention Time, hr	2	2	4	4	6	2	4	6	6	7
Aeration Tank Volume, 1	0.62	0.62	0.62	0.62	0.62	0.55	0.55	0.55	0.55	0.55
Average Influent Flowrate, 1/hr	0.310	0.310	0.155	0.155	0.103	0.275	0.138	0.091	0.091	0.078
Actual Conditions										
Duration of Test, hr	5.3	6.5	11.0	11.0	12.0	6.0	4.5	8.5	5.0	5.5
Effluent Volume, 1	1.81	2.21	1.80	1.40	1.20	1.86	1.0	0.95	0.50	0.44
Effluent Flowrate, 1/hr	0.340	0.340	0.163	0.127	0.10	0.310	0.750	0.112	0.100	0.080
Detention Time, hr	1.8	1.8	3.2	4.9	6.2	1.8	3.2	5.0	5.5	6.9
BOD, mg/1										
Influent	520	520	520	520	520	550	550	550	550	550
Effluent	220	225	130	60	40	250	150	110	75	60
BOD Reduction, percent	58	57	75	88	92	55	75	80	87	89



City of Stockton
Swift & Co. - FWPCA Project

ACTIVATED SLUDGE
BOD REMOVAL

FIGURE V-8

activated sludge aeration time is plotted against BOD concentration and BOD percent reduction. BOD removal of 90 percent was achieved in approximately 6 hours of aeration. Activated sludge clogging and foaming was a problem with Swift waste at the 92°F test temperature.

The BOD concentration of Swift wastewater used for the test was lower than the BOD measured during the field sampling program. This was attributed to congealing of the grease and fats in the sample while in cold storage and the test storage time. The congealed sludge matter on the container surfaces was not used for the pilot plant tests.

As stated previously, the major problems in the tests were foaming and clogging of the return activated sludge. In design of the plant, this consideration must be taken into account, but should be a lesser problem since tubing used in this test was 1/2 inch in diameter. As long as a velocity of 2 to 3 ft/sec is maintained in the treatment plant, sludge clogging would be avoided.

Foaming was a severe problem during these tests when the raw sewage feed rate was increased for 2 hours of aeration. With 6 hours of activated sludge aeration, the foaming was minimal. For the Swift plant, big surges of waste discharges would not occur because influent pumps discharging at designated rates will prevent excessive peak flows. Enough storage must be maintained in the pump wet pits to accommodate flow surges; the Swift flotation tanks tend to prevent excessive peak flows.

Some bulking occurred in the clarifier unit periodically. Occasional draining of excess sludge from the clarifier unit eliminated this bulking problem.

3. Test Series 2

A second series of laboratory pilot plant tests was generally similar to the first series described above, except that only one aeration and one clarification tank were used, and all elements of the system were enlarged. The activated sludge aeration and clarification units were both 2,400 ml. The raw waste feed rate was 350-400 ml/hr and the Swift wastewater was controlled by using a time clock and solenoid, cycling on-off as described for Test Series 1. The test temperatures were 90±5°F. The activated sludge was aerated at an average rate of 4 l/min. Swift wastewater used for the test was packed in dry ice and shipped to the project engineer's Los Angeles laboratory. It was stored at 35°F for two weeks before using. At the time of the test, it had a BOD of 580 to 620 mg/l. During storage in the test reservoir at 90°F, the BOD further decreased up to 10 percent. The Swift wastes maintained their typical "cooked blood" smell. The waste had a brownish-yellow color, high turbidity, and appeared to contain blood, fat, and hair.

Activated sludge collected from Hyperion Treatment Plant was concentrated and used as a seed to initiate the test.

Table V-4 summarizes the BOD of raw Swift wastewater and activated sludge test effluent. Pilot plant activated sludge effluent was collected continuously; volume and BOD were routinely measured. Detention times of 6 to 7 hours were calculated for the continuous activated sludge 4-day run. Six hours of activated sludge aeration produced a BOD reduction averaging about 90 percent. The clarified effluent after six hours settling was a pale and clear liquid. Odors were classified as musty. The activated sludge effluent contained suspended solids which settled to the bottom within 30 minutes.

From time to time excess solids were drained from the clarification tank to avoid bulking and solids overflow. The quantity was measured and a sample was taken to determine the concentration and quantity of solids. Tables V-5 and V-6 present the solids concentrations and solids balance during treatment process.

The feed rate of raw wastewater was maintained relatively constant, and this and the six-hour activated sludge aeration apparently reduced the foaming problems experienced in the Series 1 tests. Clogging of the tubing was minimal because larger piping (3/4-in. diameter) was used, and the flowrate was higher.

D. AEROBIC DIGESTION OF ACTIVATED SLUDGE

Three series of laboratory tests were run on samples of activated sludge gathered from the UCLA Sewage Treatment Plant. The purpose of these tests was to compare the effect on activated sludge digestion of a high-temperature aerobic environment with that of a conventional anaerobic environment. Some test data was also obtained to determine the effect of an aerobic environment without high temperatures.

For each series of tests, the activated sludge samples were divided into two or three portions. In the first two series, one portion was aerated at 150°F; as a control, the other portion was kept in a sealed plastic container at 75°F. In the third series of tests, one portion was aerated at 150°F, the second portion was aerated at 75°F, and the third portion was kept in a sealed plastic container at 75°F.

After 72 hour contact test periods, physical and chemical analyses were performed on each portion. Analyses were in accordance with Standard Methods for the Examination of Water and Wastewater.[1] Except for total nitrogen and grease, chemical tests were also performed on the supernatant of the sludge. The supernatant was obtained by centrifugation at 2,500 rpm at 75°F. Table V-7 summarizes the results of the laboratory tests and analyses.

In each series, two sets of plates containing nutrient agar medium (one for each sludge sample) were inoculated. One set of plates was incubated at 75°F and the other set of plates was incubated at 150°F for 24 hours. After incubation, bacterial counts were made. For incubation at 150°F the bacterial counts in the plates inoculated with the aerated activated sludge sample were consistently higher.

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[1] Standard Methods for the Examination of Water and Wastewater Including Bottom Sediments and Sludges, prepared and published jointly by the American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, 12th edition, New York, 1965.

TABLE V-4

LABORATORY TEST SERIES 2
BOD MEASUREMENTS

Sample	Elapsed Time (hrs)	Measured BOD (mg/1)	BOD Reduction (percent)
Waste (Sample Container 1)	0	620	--
" " " "	24[1]	600	3.3
Waste (Sample Container 2)	0	620	--
" " " "	24[1]	590	5.0
" " " "	48[1]	570	8.3
Effluent 1	12	70[2] 90	88.8 85.0
" 2	24	65[2] 50	89.1 90.1
" 3	36	50	91.5
" 4	48	40	93.3
" 5	60	90	85.0
" 6	72	70	88.8
" 7	84	50	91.5
" 8	96	50	91.5
" 9	108	60	90.0
" 10	120	60	90.0

---

[1] Samples were taken from the storage tank after 24 and 48 hrs to determine BOD's to find the extent of BOD reduction during storage at 90°F.

[2] Filtered effluent.

TABLE V-5

LABORATORY TEST SERIES 2
SUSPENDED SOLIDS

Source	Elapsed Time hrs	Concentration mg/1
Aeration Unit	0	10,000
	12	11,300
	24	12,500[1]
	48	9,800[1]
	72	9,000[1]
	96	9,500[1]
	120	9,150
Effluent Unit	12	500
	24	150
	36	160
	48	120
	60	200
	72	100
	84	130
	96	100
	108	100
	120	150

[1] Excess sludge removed; see Table V-6 for quantity.

TABLE V-6

LABORATORY TEST SERIES 2
SOLIDS BALANCE

Source of Solids	Quantity, mg
Clarification Unit	81,600
Collected from Aeration and Clarification Unit at the Termination of the Test	54,900
Collected from Clarification Unit	38,900
In Effluent	3,400
Total	178,800
Solids Added as Activated Sludge	40,000
Total Solids Generated	138,800

TABLE V-7

ANALYSES OF AEROBICALLY DIGESTED ACTIVATED SLUDGE

Description	Test Series 1		Test Series 2		Test Series 3		
	Control	Aerated @ 150°F	Control	Aerated @ 150°F	Control	Aerated @ 75°F	Aerated @ 150°F
Physical Characteristics							
Odor	Strong Septic	Moderate Cooked	Strong Rotten Egg	Mild Earthy	Strong Septic	Mild Earthy	Mild Cooked
Color	Black	Dk Brown	Black	Lt Brown	Black	Brown	Lt Brown
Total Solids, percent by wet wt	1.02	0.60	0.58	0.23	0.44	0.30	0.32
Moisture Content, percent by wet wt	98.98	99.40	99.42	99.77	99.56	99.70	99.68
Incombustible Solids, percent by wet wt	0.54	0.50	0.42	0.09	0.31	0.20	0.21
Settled Sludge, percent by volume	65	35	50	10	65	50	45
Time of Centrifugation	10	10	10	10	15	15	15
Centrifuged Sludge, percent by volume	42	20	12	2	11.2	7.2	6.2
Supernatant Appearance	Clear	Cloudy	Clear	Cloudy	Slightly Cloudy	Clear	Cloudy
Total Dissolved Solids in Supernatant, percent by wet wt	0.23	0.21	0.07	0.03	0.21	0.04	0.08
Chemical Characteristics, mg/l except pH							
pH	6.9	7.7	6.5	7.5	7.1	7.7	8.2
Nitrate (NO_3)	0.20	1.80	0.15	0.55	0.05	0.23	0.70
Nitrite (NO_2)	0.01	0.16	0.01	0.14	0.02	0.06	0.30
Organic Nitrogen (N)	30	55	28	10	21	9	13
Total Kjeldahl Nitrogen (N)	150	120	205	74	170	96	118
Phosphate (PO_4)	62	22	24	18	16	12	12
Sulfate (SO_4)	10	220	15	80	70	170	140

TABLE V-7 (Continued)

ANALYSES OF AEROBICALLY DIGESTED ACTIVATED SLUDGE

Description	Test Series 1		Test Series 2		Test Series 3		
	Control	Aerated @ 150°F	Control	Aerated @ 150°F	Control	Aerated @ 75°F	Aerated @ 150°F
Chemical Characteristics, mg/l except pH (continued)							
Volatile Acids	12	24	60	6	29	7	5
Sulfide (S)	0	0	0	0	0	0	0
Grease	720	280	500	100	600	280	200
Dissolved Oxygen	0.2	1.0	0.8	6.4	0.6	1.5	3.0
BOD, 72 hrs	—	—	—	—	220	100	90
BOD, 5 days	180	—	520	90	320	180	180
Bacterial Counts, cells/ml							
75°F Incubation	$3x10^5$	$7x10^3$	$3x10^5$	$3x10^3$	$7x10^5$	$2x10^6$	$1x10^4$
150°F Incubation	$2x10^3$	$7x10^6$	$1x10^3$	$5x10^5$	$2x10^3$	$2x10^3$	$2x10^6$

than were the bacterial counts in the plates inoculated with the unaerated sample. At 75°F incubation, bacterial counts were higher in the unaerated samples than in the aerated samples. This indicated that stabilization of the sludge at high temperature was brought about by a different group of bacteria which grew actively at 150°F and were unable to grow at 75°F. The bacteria that grew at 150°F stabilized the sludge more rapidly than the bacteria that grew at 75°F.

E. HYDROGEN PEROXIDE APPLICATION

1. General

Hydrogen peroxide previously had been investigated as an oxidant for the elimination of odors and sulfides in anaerobic sewages; laboratory pilot plant tests appeared promising enough to warrant further field tests. Hydrogen peroxide had been found to break down in sewage to release molecular oxygen due to the action of the enzyme catalase and heavy metal catalysts. Apparently the hydrogen peroxide molecule also had an inhibitory effect on sulfur bacteria, reducing sulfate to sulfide. The quantity of hydrogen peroxide required to protect a sewer against corrosion and odor is dependent upon the length to be protected, flow quantities, and half-life of hydrogen peroxide in the particular wastewater. Half-lives in domestic sewage had been found to be 30 to 60 minutes.

The upstream section of the Southern Industrial Trunk provided a controlled test condition. For all practical purposes, the only sewage flowing in the 30-in. diameter length of trunk sewer was Swift wastewater. It was hypothesized that continuous application of hydrogen peroxide at a rate of 5 mg/l might be effective for a time period of 60 to 120 minutes. This would have provided some protection in the 30-in. trunk sewer from hydrogen sulfide formation if the initial peroxide demand was not excessive. The laboratory and field testing program was a cooperative effort of the City of Stockton, FMC Corporation, and the Project Engineers.

2. Preliminary Laboratory Tests

Prior to the field tests, preliminary bench tests were carried out to estimate the effectiveness of hydrogen peroxide application for the elimination of sulfides. Jar tests were made on Swift wastewater which contained the industrial waste as well as plant sanitary waste. Since the wastewater sample used had been refrigerated at 35°F and stored for about one month, it was aerated for 20 minutes to strip sulfides to 2 to 3 mg/l. Hydrogen peroxide additions varied from 1 to 5 mg/l, and the temperature was controlled at 84°F ± 2°F. Reaction time periods varied from 2 minutes to 6 hours. The results, which are presented in Table V-8, indicated that hydrogen peroxide effectively eliminated sulfides. This is illustrated in Figure V-9, where at a dosage of 3 mg/l, sulfides were reduced to zero over a period of

TABLE V-8

LABORATORY TESTS FOR HYDROGEN PEROXIDE APPLICATION[1,2]

Elapsed Time min	Test 1						Test 2					
	Control			1 mg/l H_2O_2 Addition			Control			2 mg/l H_2O_2 Addition		
	D.O. mg/l	pH	H_2S mg/l	D.O. mg/l	pH	H_2S mg/l	D.O. mg/l	pH	H_2S mg/l	D.O. mg/l	pH	H_2S mg/l
0	0.2	6.5	2.5	0.2	6.5	2.5	0.2	6.5	2.5	0.2	6.5	2.5
2	0.3	6.6	2.5	2.0	6.7	1.8	0.2	6.6	2.4	2.6	6.9	1.5
5	0.2	6.6	2.4	2.3	6.8	1.0	0.2	6.5	2.5	3.2	7.0	0.9
10	0.2	6.5	2.5	2.6	6.7	0.8	0.2	6.5	2.5	3.6	7.1	0.6
20	0.3	6.7	2.5	3.0	6.9	0.6	0.3	6.7	2.5	4.0	7.2	0.3
30	0.3	6.6	2.4	3.5	7.0	0.4	0.3	6.6	2.4	4.5	7.2	0
40	0.2	6.6	2.3	3.8	7.1	0.2	0.2	6.6	2.3	4.9	7.3	0
60	0.2	6.6	2.5	3.2	7.3	0.4	0.2	6.6	2.5	4.5	7.3	0
90	0.3	6.5	2.5	2.4	7.1	0.6	0.3	6.5	2.5	4.0	7.4	0.2
120	0.3	6.7	2.4	1.2	7.4	0.8	0.3	6.7	2.4	3.2	7.5	0.5
180	0.2	6.7	2.4	0.8	7.5	1.1	0.2	6.7	2.4	2.0	7.6	0.8
240	0.2	6.6	2.5	0.7	7.6	1.4	0.2	6.6	2.5	1.0	7.7	1.0
300	0.2	6.8	2.5	0.6	7.8	1.7	0.2	6.8	2.5	0.8	7.9	1.2
360	0.2	6.7	2.5	0.3	8.0	2.0	0.2	6.7	2.5	0.6	8.1	1.5

TABLE V-8 (Continued)

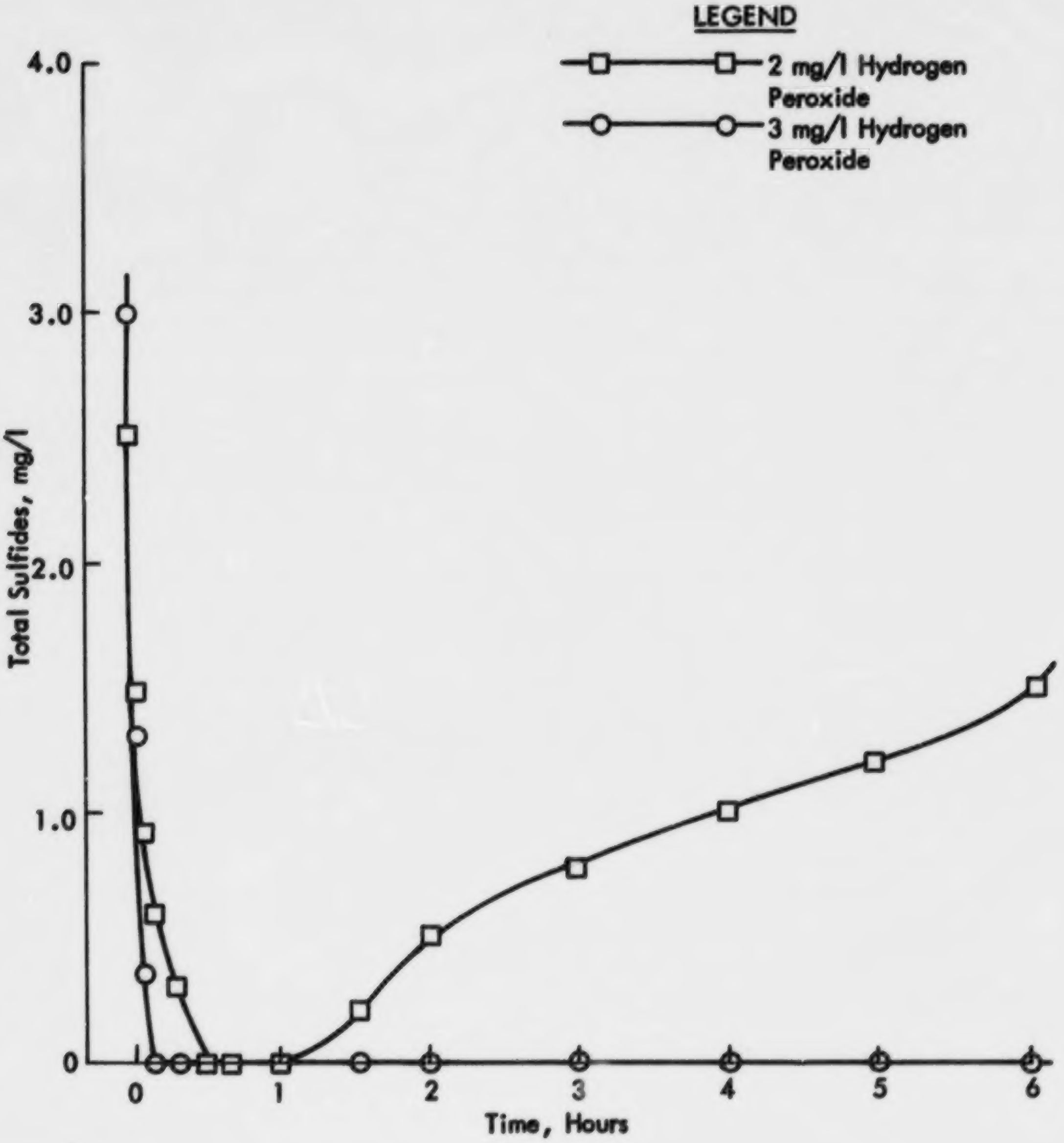
LABORATORY TESTS FOR HYDROGEN PEROXIDE APPLICATION[1,2]

Elapsed Time min	Test 3						Test 4					
	Control			3 mg/1 H_2O_2 Addition			Control			5 mg/1 H_2O_2 Addition		
	D.O. mg/1	pH	H_2S mg/1	D.O. mg/1	pH	H_2S mg/1	D.O. mg/1	pH	H_2S mg/1	D.O. mg/1	pH	H_2S mg/1
0	0.2	6.5	3.0	0.2	6.5	3.0	0.2	6.5	3.0	0.2	6.5	3.1
2	0.2	6.6	3.0	3.3	6.8	1.3	0.2	6.6	3.0	3.9	6.9	1.0
5	0.2	6.5	3.0	4.0	6.9	0.4	0.2	6.5	3.0	5.0	7.1	0.2
10	0.3	6.5	3.1	5.1	7.1	0	0.3	6.5	3.1	5.6	7.2	0
20	0.3	6.6	3.0	5.4	7.1	0	0.3	6.6	3.0	6.0	7.3	0
30	0.2	6.6	3.1	5.6	7.4	0	0.2	6.6	3.1	6.2	7.1	0
40	0.3	6.5	3.0	6.0	7.5	0	0.3	6.5	3.0	6.6	7.0	0
60	0.3	6.5	3.0	5.5	7.3	0	0.3	6.5	3.0	6.1	7.0	0
90	0.2	6.6	3.0	4.8	7.4	0	0.2	6.6	3.0	5.6	7.1	0
120	0.3	6.5	3.1	4.0	7.3	0	0.3	6.5	3.1	5.0	7.1	0
180	0.3	6.6	3.0	3.5	7.3	0	0.3	6.6	3.0	4.0	7.1	0
240	0.3	6.5	3.1	3.0	7.3	0	0.3	6.5	3.1	3.0	7.1	0
300	0.3	6.5	3.0	2.0	7.3	0	0.3	6.5	3.0	2.3	7.1	0
360	0.3	6.6	3.1	1.0	7.3	0	0.3	6.6	3.1	1.5	7.1	0

---

[1] Sewage used for tests was Swift effluent that had been stored at 39°F for about one month. Prior to test, sewage was aerated for 20 minutes.

[2] Test run at 84°F.



City of Stockton
Swift & Co. - FWPCA Project

EFFECT OF HYDROGEN PEROXIDE
ON SULFIDE CONTENT
IN LABORATORY TESTS

FIGURE V-9

six hours. A dosage of 2 mg/l reduced sulfides to zero, but did not prevent redevelopment of sulfides. These results were encouraging.

The Pomeroy Method was used to determine total sulfides and a Beckman oxygen probe was used to measure dissolved oxygen. The Beckman oxygen probe was found to be affected by the Swift waste and the data obtained from this probe was determined to be erroneous. This conclusion was reached because the control sample indicated a slight reading of 0.2 to 0.3 mg/l dissolved oxygen when no peroxide had been introduced into the sample whereas with hydrogen peroxide application, dissolved oxygen concentration as high as 6.6 mg/l for the treated samples were measured. Only about 2.5 mg/l of oxygen equivalent was added in 5 mg/l of hydrogen peroxide. Apparently, the Beckman probe, which does not measure hydrogen peroxide, was affected by other components in the system besides molecular oxygen.

3. Field Tests

Prior to field application of hydrogen peroxide, City of Stockton personnel ran a sulfide profile in the 30-in. diameter section of the Southern Industrial Trunk between the Swift plant and Airport Way. Figure V-10 shows the section of trunk sewer under study during these field tests.

This field control test was run on December 4, 1969, and indicated that sulfide development did not occur until about 3,500 ft downstream from the Swift flotation tanks and about 1,500 ft downstream from the Swift Parshall flume. At Manhole 47 the sulfides gradually increased throughout the remainder of the 30-in. trunk sewer to a value of 1.2 mg/l at Airport Way. The resident time in the sewer to Manhole 47 from the source of the waste was calculated to be 20 to 25 minutes.

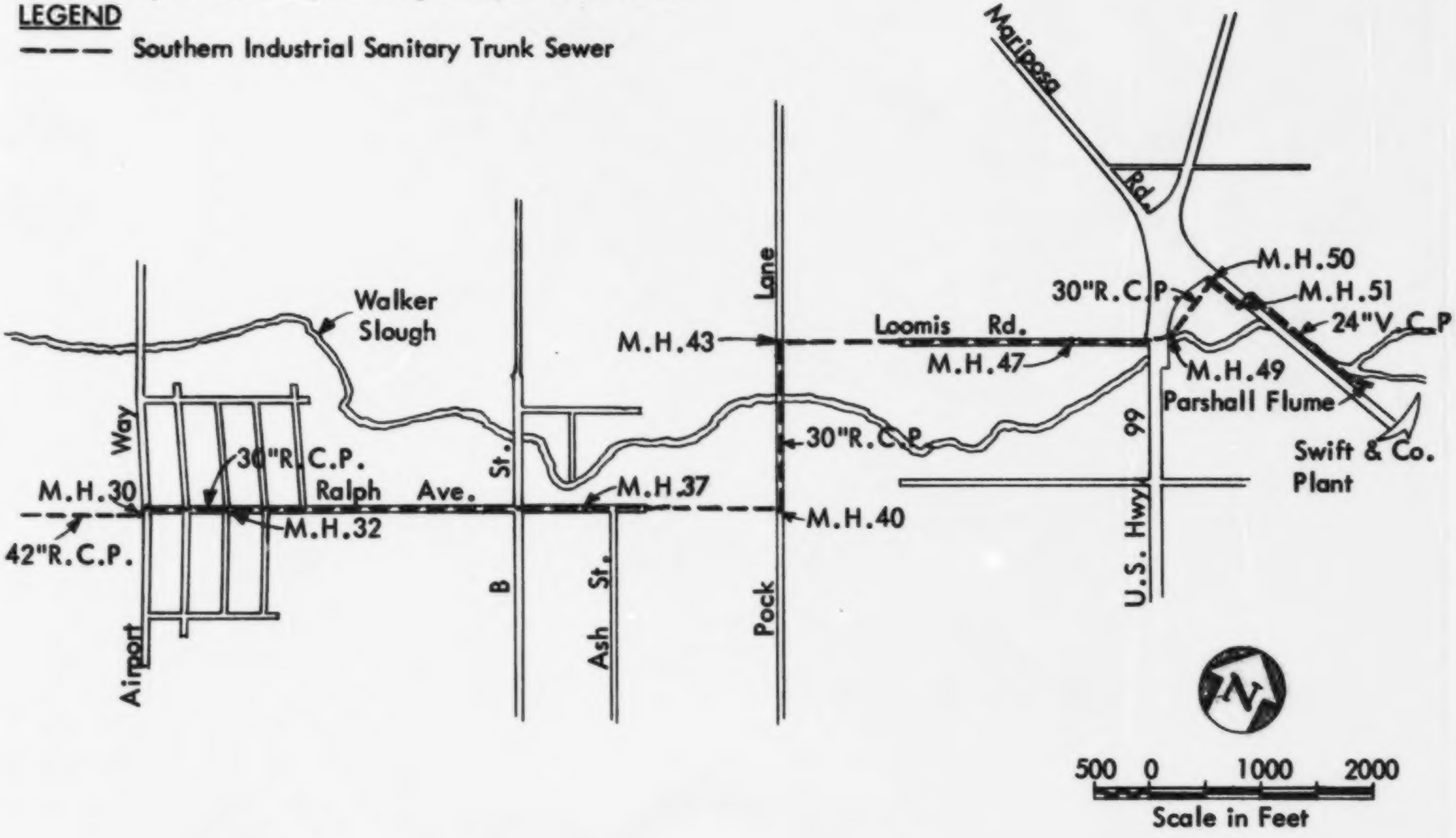
For the field tests, hydrogen peroxide was added to the Swift wastewater at Manhole MK-7 (see Figure II-2) about 250 ft downstream of the Swift flotation tanks. A Model 78 Sigmamotor pump (T-8 Series) and 1/4-in. Tygon tubing were used to feed the hydrogen peroxide solution (FMC Corporation-BECCO 35 percent grade hydrogen peroxide). An initial free hydrogen peroxide dose rate of 5 mg/l, based on a 1.2 mgd, was established. With the feed pump at this setting and because the diurnal flowrate at the plant drops off to about 0.3 to 0.4 mgd at night, the actual dosage was as much as 15 to 20 mg/l during the periods of low flow. This provided slug peroxide doses that might kill slime growths. Reduced dosages were planned for subsequent days to determine minimum dosages.

After resolving several minor mechanical feeding problems, the first tests were run in the sewer on December 10, 1969. The test results are described in Table V-9. The field studies indicated that peroxide had little effect on the sulfide concentration, and that peroxide was completely decomposed before reaching the Parshall flume. The resident time from the point of hydrogen peroxide addition to the Parshall flume was 16 minutes, which indicated a very short half life.

Source: City of Stockton, Drawing 6107, dated 9-16-59

LEGEND

—— —— Southern Industrial Sanitary Trunk Sewer


Mariposa
Rd.
M.H.50
30"R.C.P
M.H.51
24"V.C.P
Walker
Slough
Lane
M.H.43
Loomis Rd.
M.H.47
M.H.49
Parshall Flume
Swift & Co.
Plant
Way
30"R.C.P.
M.H.30
Ralph Ave.
St.
M.H.37
30"R.C.P
M.H.40
M.H.32
42"R.C.P.
99
U.S. Hwy
B
Ash St.
Pock
Airport
N
500 0 1000 2000
Scale in Feet

City of Stockton
Swift & Co. - FWPCA Project

TRUNK SEWER HYDROGEN PEROXIDE FIELD TEST

FIGURE V-10

TABLE V-9

HYDROGEN PEROXIDE FIELD TEST RESULTS

	Control Test, No H_2O_2 Addition 12/4/69			5 mg/l H_2O_2 Addition 12/10/69				10 mg/l H_2O_2 Addition 12/11/69					10 mg/l H_2O_2 Addition 12/11/69			
Sample Station	Temp. °F	pH	S^2 mg/l	Time P.M.	D.O. mg/l	H_2O_2 mg/l	S mg/l	Time A.M.	pH	D.O. mg/l	H_2O_2 mg/l	S mg/l	Time P.M.	D.O. mg/l	S mg/l	H_2O_2 mg/l
MK-7[3]	—	—	—	1:45	3.8	0	0.1	10:30	7.4	3.0	0	0.05	2:00	1.0	0.1	0
Parshall Flume	90	6.8	0	2:05	0.6	0	0.1	10:40[4]	8.1	1.8	0	0	2.08	0.4	0.1	0
MH 51	90	6.9	0	—	—	—	—	—	—	—	—	—	—	—	—	—
MH 49	89	7.3	0	—	—	—	—	—	—	—	—	—	—	—	—	—
MH 47	88	6.9	0.2	2:15	0.2	0	0.2	10:50	7.8	0	0	0.2	2:15	0	0.3	0
MH 43	88	7.0	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—
MH 40	87	6.9	0.3	2:20	0	0	0.4	11:01	8.0	0	0	0.4	2:24	0	1.0	0
MH 37	87	7.0	0.3	2:30	0	0	0.9	11:16	7.8	0	0	0.6	2:32	0	1.2	0
MH 32	87	6.7	0.7	2:41	0	0	1.3	11:26	7.9	0	0	0.8	2:39	0	1.4	0
MH 30	86	6.7	1.2	2:55	0	0	2.4	11:31	7.8	0	0	1.2	2:41	0	2.7	0
MH 21	—	—	—	—	—	—	—	11:41	7.6	0	0	4.4	2:53	0	4.0	0
(S-10)[6]	—	—	—	3:15	0	0	2.5	11:51	7.3	0	0	2.5	3:05	0	5.2	0
(S-11)[7]	—	—	—	3:45	0	0	2.2	—	—	—	—	—	—	—	—	—

[1] See Figure V-10 for location of sample station.

[2] Analyses for sulfides is for total sulfides.

[3] Point of hydrogen peroxide application; see Figure II-2.

[4] 1.3 mgd, recorded at Parshall flume.

[5] 1.0 mgd recorded at Parshall flume.

[6] See Figure II-1.

[7] Main Water Quality Control Plant influent.

In additional field tests, the hydrogen peroxide addition rate was doubled to 10 mg/l, based on 1.2 mgd flow. This peroxide dosage was fed overnight and produced an effective dosage rate of 30 to 40 mg/l due to the diurnal flow variations.

Two sets of field analysis data were obtained on December 11, 1969 (see Table V-9). The field test data obtained on the second day indicated no apparent benefit with the peroxide other than the reduction of the initial sulfides in the Swift wastes to zero. The rapid hydrogen peroxide decomposition rate indicated that application of hydrogen peroxide to the raw Swift effluent was not technically and economically feasible; the field test was discontinued.

4. Hydrogen Peroxide Decomposition Rates

During the field test, samples of the Swift wastewater excluding sanitary sewage were obtained for laboratory studies to determine the rate of peroxide decomposition. Samples were obtained on December 9 and 12, 1969, from Manhole MK-7, upstream of the point where hydrogen peroxide was being applied.

Laboratory tests were run on December 10 and 12, 1969 to obtain information on the effect of blood and other wastewater components in the fresh Swift effluent. A decomposition rate 5 to 10 times faster than rates for domestic sewage or cannery wastewaters was measured.

Decomposition rates were computed based on the differences between dissolved oxygen concentration determined by the Winkler Method. Oxygen was measured by a corrected Beckman oxygen probe that recorded only molecular oxygen (not the hydrogen peroxide). The oxygen probe was calibrated using the Winkler DO data after all the peroxide had been decomposed. The peroxide decomposition rate equation can be expressed as follows:

$$-\frac{d(H_2O_2)}{dt} = k(H_2O_2) \qquad (1)$$

Where:

k is the decomposition rate constant expressed per unit time,
H_2O_2 is the concentration of hydrogen peroxide,
t is time

Rearranging and integrating equation (1), there results:

$$(H_2O_2) = (H_2O_2)_{\text{initial}} \exp(-kt) \qquad (2)$$

Equation (2) indicates that a plot of $l_n H_2O_2$, versus t will be a straight line, and that the negative of the slope of the resulting straight line will equal the rate constant k.

For convenience, the decomposition rate can be expressed as the half life of peroxide. The half life is the amount of time required to reduce any given concentration of peroxide to one-half of its value and can be calculated from the following expression:

$$\text{Half life } t_{(1/2)} = \frac{0.693}{k}$$

The hydrogen peroxide decomposition rate results for the sample collected on December 12, 1969, are shown in Table V-10 and Figure V-11. The decomposition rate constant k was found to be 0.11/min, and the half life was computed to be 6.2 minutes.

The rapid rate of decomposition was probably due to the blood content of the waste. Blood catalyzed the decomposition of peroxide because of the organic iron compounds present, such as hemoglobin and catalase.

Six liters of Swift wastewater collected on December 12, 1969, were mixed with one liter of return activated sludge to prepare a batch mixed liquor sample for the treatment of the high BOD content of the waste. Aeration was used as a source of oxygen and as a means of activated sludge mixing. The return activated sludge and raw waste sample had the following analyses:

Swift Raw Wastewater:	Total Carbon	= 1,130 mg/l
Return Activated Sludge:	Suspended Solids	= 7,190 mg/l
	Volatile Suspended Solids	= 5,560 mg/l

The mixed liquor was aerated over the weekend at 76°F and then allowed to settle gravimetrically on Monday morning, December 15, 1969. The settled sample had a total carbon concentration of 43 mg/l which represented about a 96 percent total carbon reduction. Hydrogen peroxide decomposition rate tests were made on the settled and decanted liquor from the biological treatment. Biological treatment of Swift wastewater eliminated the components that catalyzed the decomposition of peroxide, extending its half life to 95 minutes. With such an effluent half life, the hydrogen peroxide would probably be effective for sulfide and corrosion control in the downstream trunk sewer.

TABLE V-10

DECOMPOSITION OF HYDROGEN PEROXIDE IN SWIFT WASTEWATER

Time min	Dissolved Oxygen, mg/l (1) By Probe	Dissolved Oxygen, mg/l (2) By Winkler Method	Hydrogen Peroxide, mg/l (2) - (1)
Untreated Waste[1]			
0.5	0.7	10.5	9.8
1	1.0	10.2	9.2
5	3.8	9.7	5.9
10	6.7	9.2	2.5
15	9.2	9.0	0
Treated Waste[2]			
0.5	6.0	17.0	11.0
1	6.2	17.0	10.8
25	7.8	17.0	9.2
60	9.1	17.0	7.9

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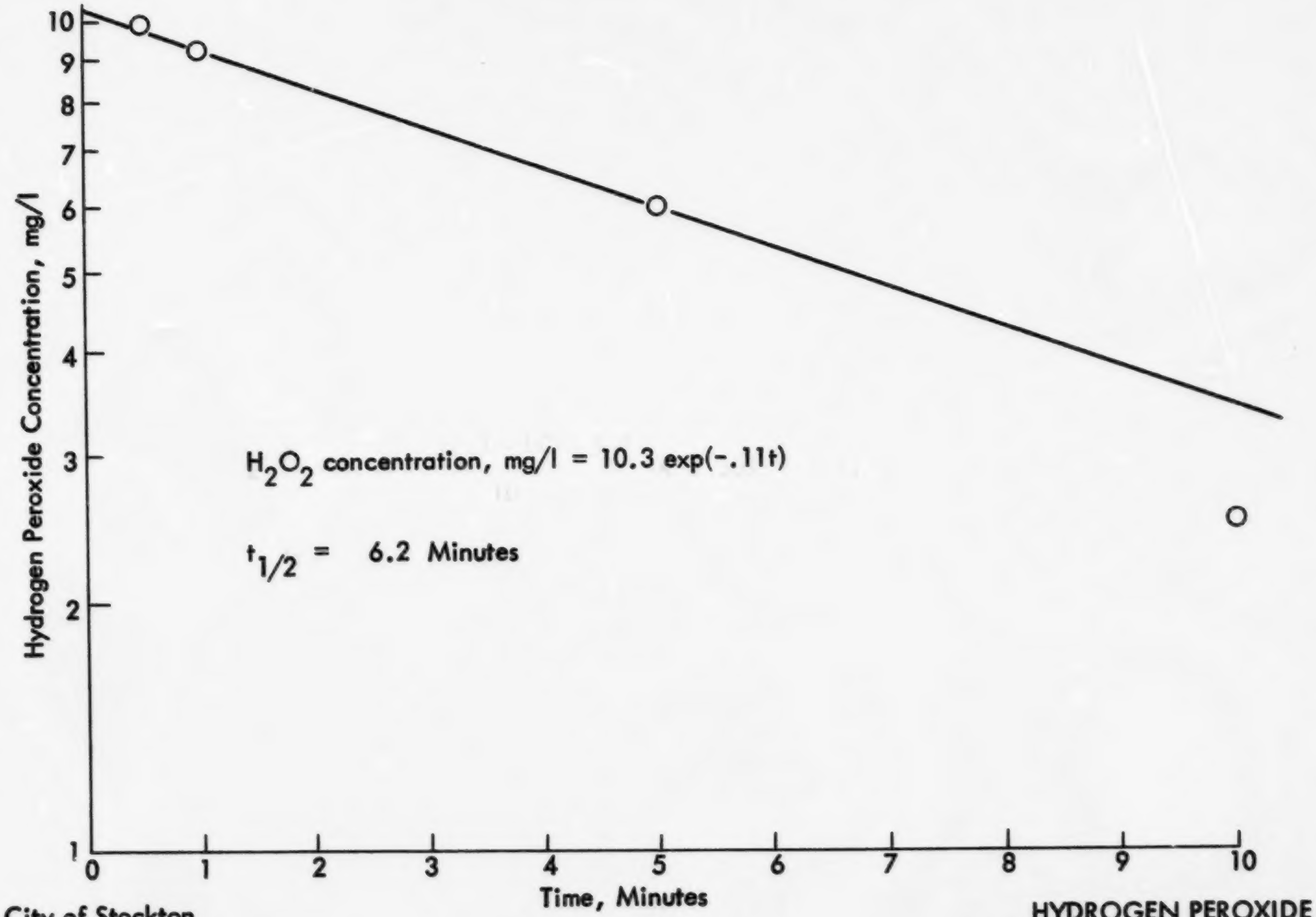
[1] Sampled on December 12, 1969, and tested.

[2] Aerated for 66 hours.



City of Stockton
Swift & Co. - FWPCA Project

HYDROGEN PEROXIDE
DECOMPOSITION RATE CURVE
FIGURE V-11

VI. UPSTREAM ACTIVATED SLUDGE TREATMENT PLANT

A. GENERAL

Based on the pilot plant tests, three alternative activated sludge treatment plants were considered for installation at the Swift meat packing site. Each activated sludge plant would operate using some of the principles of the Kehr process, and some principles of the conventional six-hour standard rate activated sludge process. The Kehr process is a parallel development to extended activated sludge aeration; it was developed by Professor Kehr of the Technishe Hochschule in Hanover, Germany.[1] The FMC Corporation has studied this process and performed pilot scale tests under F.W.P.C.A. contract.[2] They reported that the modified Kehr process was well-suited for high-strength cannery wastewater with BOD's of 1000 mg/l or more. The process uses suspended solids with concentrations of mixed liquor ranging from 6000 to 14,000 mg/l; there is little sludge wasting. The high solids concentration of the process, when coupled with other appropriate physical factors for maintaining an optimum activated sludge environment, provides a well buffered solution capable of treating high-strength wastes.

Professor Kehr was contacted during this study to obtain first-hand information on his process. Based on his work with domestic sewage, Professor Kehr felt that the Kehr process would have to be modified for treatment of meat packing wastes, due to the nature of the wastewater, its high grease concentration, the potential scum, foaming, and odor problems. He stated that for final treatment, the Swift effluent would not be suitable for disposal to receiving waters. However, the proposed effluent from the Swift upstream activated sludge treatment plant will be discharged into the Southern Industrial Trunk and will receive further treatment at the Main Water Quality Plant prior to disposal into the receiving waters of the San Joaquin River.

FMC reported that at times the Kehr activated sludge treatment process caused difficulties in the liquid-solid separation of activated sludge effluent in the clarifier. However, this was not a primary consideration for the upstream treatment plant at Swift because excess activated sludge can be discharged into the trunk sewer for final processing at the City's Main Water Quality Plant. The sludge may beneficially act as a seed, thereby improving the downstream treatment plant efficiencies.

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[1] Kehr, Dietrich, "Aerobic Sludge Stabilization in Sewage Treatment Plants", Third International Conference on Water Pollution Research, Section 11, Paper No. 8, Conference Center, Messegelande Theresienhohe, Munich, Germany.

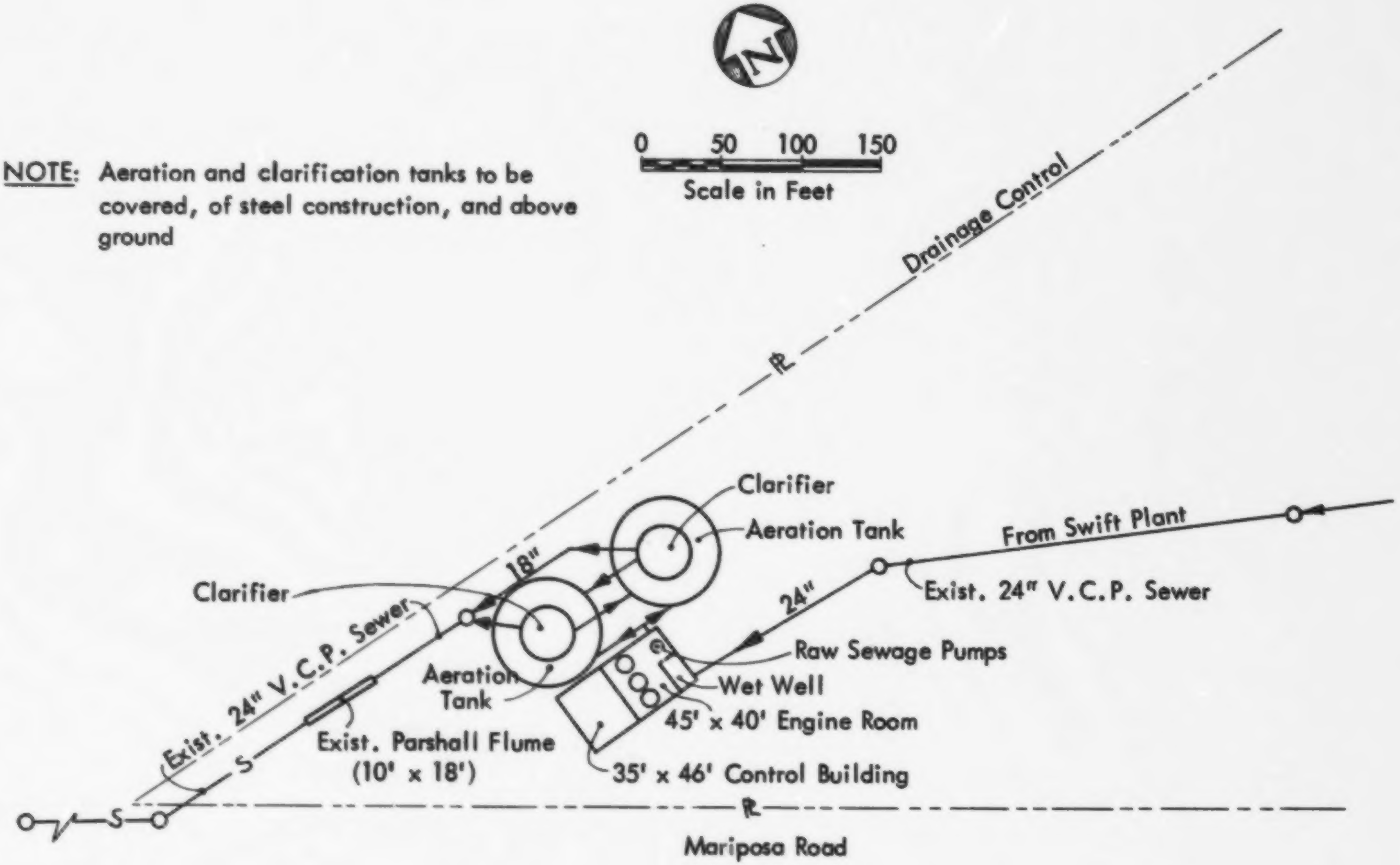
[2] Cannery Waste Treatment by the Kehr Activated Sludge Process, Report R-2795, FMC Corporation, Environmental Engineering Department, Central Engineering Laboratories, prepared for the Federal Water Pollution Control Administration, June 1969.

High BOD demand industrial wastes often cause upsets in conventional municipal activated sludge treatment plants because of the shock loading effect of variable volume toxic flows. Stockton's Main Water Quality Plant was designed to operate as a fail-safe system to treat all wastewater regardless of strength or quantity, in order to conform to strict discharge requirements. The plant is therefore more elaborate and oversized than is necessary for treating the average dry-weather, non-canning season sanitary sewage flows. Construction of an activated sludge treatment plant upstream at Swift would relieve the peak overload conditions at the Main Water Quality Plant. The major difference between the three alternative types of activated sludge plants were the methods of aeration: 1) compressed air diffusion; 2) mechanical floating aerators; and 3) brush aerators.

Based on the pilot scale test results, described in Chapter V, and on the Project Engineer's and the FMC tests, six hours detention time in the activated sludge aeration basin and three hours detention time in the settling basins were established as design criteria. Land area, cost, and related constraints were reviewed prior to making this decision. A six-hour aeration period is a standard detention time for conventional activated sludge treatment plants and should provide adequate time for the Swift waste oxygen uptake. With six hours detention, the unit loading would be 300 lb BOD/1000 cu ft of aeration tank. An average 90 percent reduction in BOD and 80 percent reduction in total organic carbon (TOC) should be achieved. The six-hour aeration should produce high removals of nitrogen and phosphorous (75%). The aeration basin would be operated as a complete mix. Large quantities of air are required by the Swift waste in comparison to the liquid volumetric capacity of the basin; consequently, plug flow oxygenation would not be practical.

The plants are designed for an average flow of 1.5 mgd with 1200 mg/l BOD, or 15,000 lb BOD/day. As shown on Figures II-5 to II-10, the volumetric and pollution load vary throughout the day, with highest flows and waste load occurring during the day and early evening. Minor flow occurs over the weekends. The high solids concentration in the mixed liquor should act as a treatment buffer for shock dosages and during the intervals of low flow. During periods of low flow, the sludge will endogenously respirate and the rate of air addition will be decreased. Design criteria for each of the three plants are presented in Appendices H, I, and J.

Figures VI-1 to VI-3 are schematic layouts of the alternative treatment plants. The plants would be constructed upstream of the Parshall flume on Swift and Company property. The plants would require about one to two acres of the triangular shaped parcel of land on the most westerly corner of Swift's property. Additional land for buffer area would be desirable. Trees and other landscaping would be installed both as a buffer and to improve the aesthetic appearance of the treatment works. The landscaping would be a visual improvement over the present open field area. To reduce potential odor nuisances, the aeration basins would be covered.


0
50
100
150
Scale in Feet
Drainage Control
℞
Clarifier
Aeration Tank
From Swift Plant
Exist. 24" V.C.P. Sewer
24"
18"
Clarifier
Exist. 24" V.C.P. Sewer
Aeration Tank
Raw Sewage Pumps
Wet Well
45' x 40' Engine Room
35' x 46' Control Building
Exist. Parshall Flume (10' x 18')
S
S
℞
Mariposa Road

NOTE: Aeration and clarification tanks to be covered, of steel construction, and above ground

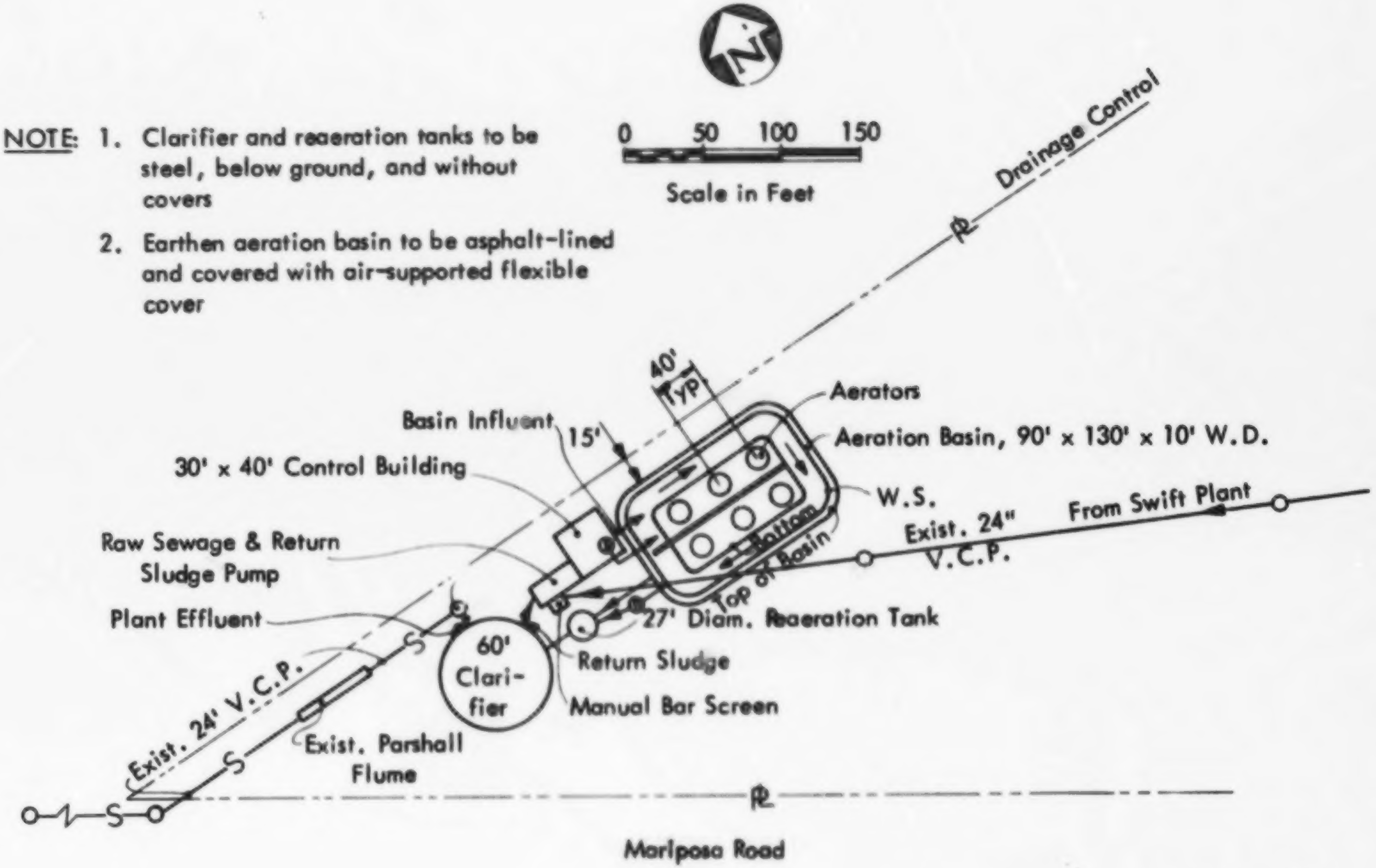
City of Stockton
Swift & Co. - FWPCA Project

UPSTREAM TREATMENT PLANT LAYOUT
COMPRESSED AIR DIFFUSION SYSTEM

FIGURE VI-1

NOTE: 1. Clarifier and reaeration tanks to be steel, below ground, and without covers

2. Earthen aeration basin to be asphalt-lined and covered with air-supported flexible cover


N
0
50
100
150
Scale in Feet
Drainage Control
℄
40' Typ.
Aerators
Aeration Basin, 90' x 130' x 10' W.D.
Basin Influent
15'
30' x 40' Control Building
W.S.
From Swift Plant
Exist. 24" V.C.P.
Bottom
Top of Basin
Raw Sewage & Return Sludge Pump
Plant Effluent
27' Diam. Reaeration Tank
60' Clarifier
Return Sludge
Manual Bar Screen
Exist. 24' V.C.P.
S
Exist. Parshall Flume
℄
Mariposa Road

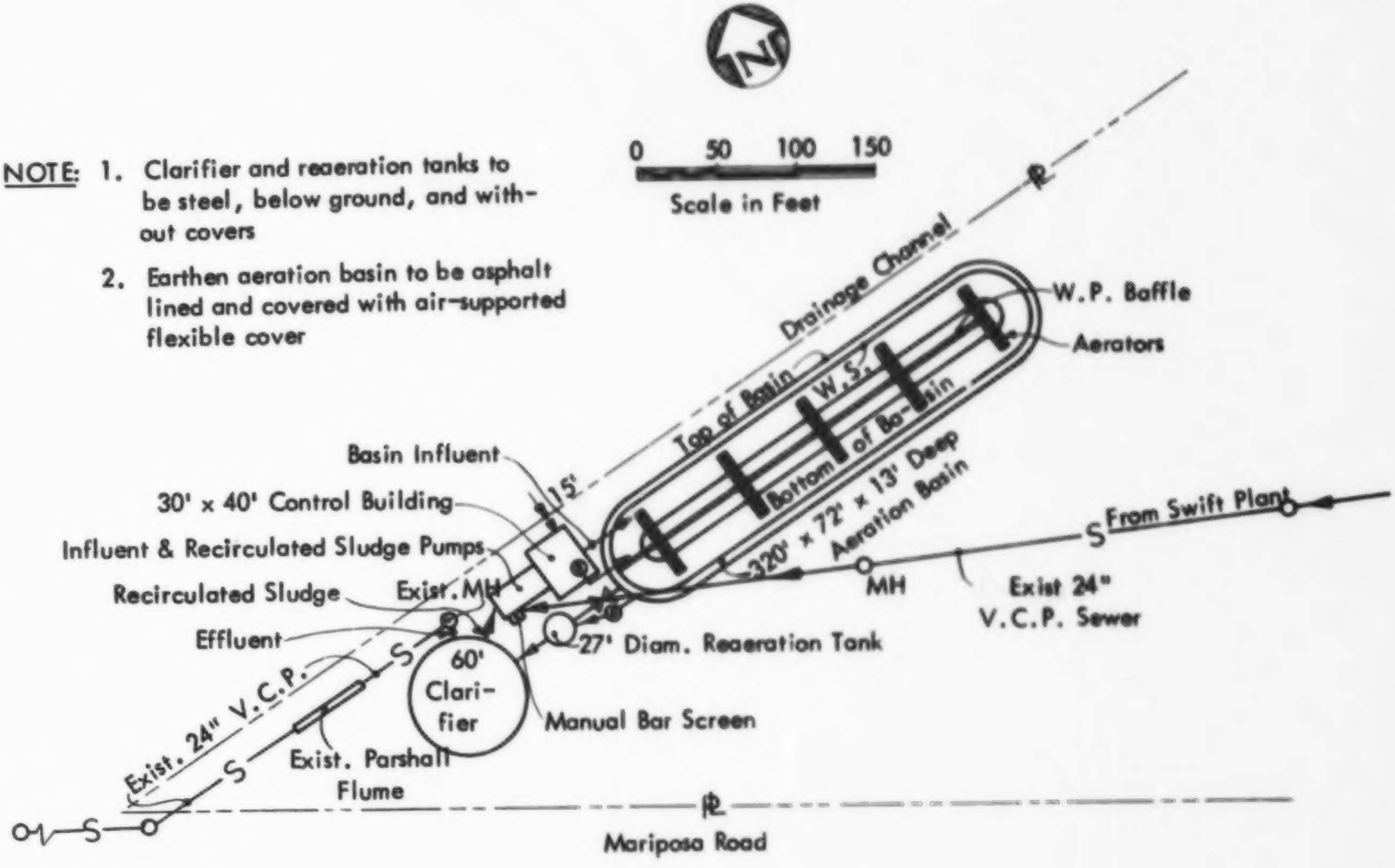
City of Stockton
Swift & Co. - FWPCA Project

UPSTREAM TREATMENT PLANT LAYOUT
MECHANICAL FLOATING AERATORS

FIGURE VI-2

NOTE: 1. Clarifier and reaeration tanks to be steel, below ground, and without covers

2. Earthen aeration basin to be asphalt lined and covered with air-supported flexible cover


0 50 100 150
Scale in Feet
N
Drainage Channel
W.P. Baffle
Aerators
Top of Basin
W.S.
Bottom of Basin
320' x 72' x 13' Deep Aeration Basin
Basin Influent
15'
30' x 40' Control Building
Influent & Recirculated Sludge Pumps
Recirculated Sludge
Exist. MH
Effluent
S
From Swift Plant
MH
Exist 24" V.C.P. Sewer
27' Diam. Reaeration Tank
60' Clarifier
Manual Bar Screen
Exist. 24" V.C.P.
Exist. Parshall Flume
℄
Mariposa Road

City of Stockton
Swift & Co. - FWPCA Project

UPSTREAM TREATMENT PLANT LAYOUT
MECHANICAL BRUSH AERATORS

FIGURE VI-3

B. COMPRESSED AIR DIFFUSION SYSTEM

Two aeration and two settling basins would be used. (See Figure VI-1 and Appendix H). Piping and valves would interconnect the basins to provide the operational flexibility to operate in series or in parallel. The clarifier would be surrounded by the aeration section. The aeration and settling basins would be steel tanks above ground. Steel covers would provide odor control, with blowers pumping air from one tank through the liquid in the second tank. High oxygen uptake is the major concern for the high rate activated sludge process. Conservative transfer rates were assumed: aeration with 4.3 percent absorbed using conventional air diffusers. The cost estimate was prepared assuming the use of conventional diffusers. Provisions were included for extra large piping in case additional blower capacity is needed. The surface rise rate of the clarifier is relatively high for a high solids unit: 80 lb/sq ft. However, overflow of excess sludge to the sewer is planned. The primary purpose of the clarifier is for activated sludge return.

Competent operation will be necessary with this high rate activated sludge process to prevent plant upsets, foaming, scum problems and to achieve the desired treatment efficiency. Of the three alternative systems the compressed air diffusion system would provide the best control. In addition, this system provides for oxygen transfer with less turbulence than the mechanical aerators, and inherently enables better control of foaming, scum removal and sludge recirculation.

C. MECHANICAL FLOATING AERATORS

Six surface aerators would be installed in an earthen basin lined with a waterproof membrane, as shown in Figure VI-2 and Appendix I. The aerators would float on pontoons chained into position. Oxygenation would be accomplished by pumping wastewater from below the surface and discharging it readily. Oxygen transfer would occur by contact of the spray with the atmosphere and by entrainment of air as the liquid falls back into the basin surface. Surface aerators reportedly can draw liquid from the bottom of 10 ft deep basins. Activated sludge solids would be maintained in suspension by the high mixing rate produced by the aerators. A conservative 2 lbs/HP/hr oxygen transfer rate was used.

For odor control, a flexible air supported cover would be installed over the aeration basin. The cover would be inflated to a pressure of about 1 psi. Excess air would be drawn from the aeration basin, pressurized to 7.5 psi, and treated by being diffused through a reaerated activated sludge tank. It would provide one hour detention. In addition to removing most of the noxious odors, the reaeration tank would provide the polishing treatment necessary to achieve an average BOD Swift waste reduction of 90 percent. A 15 ft deep steel tank would be used. The reaeration tank effluent would be discharged to a clarifier for 3-hr settling detention, sludge recirculation, and effluent discharge to the Trunk Sewer.

Operating control for this type of unit would be more difficult than with a compressed air diffusion system. Only by increasing the aeration basin detention time, from six to seven hours, and adding the reaeration basin could comparable removal efficiencies be expected.

D. MECHANICAL BRUSH AERATORS

Six surface aerators would be installed in an earthen basin lined with a waterproof membrane. (See Figure VI-3 and Appendix J). The aerators would be steel brush-like rotors which revolve on a horizontal axis. The tip of the brush would be submerged up to 10 inches. As it revolves, the activated sludge would be churned, creating a flow of wastewater from below the surface to spray in the direction of the rotor movement. Oxygen transfer would occur by contact of the spray with the atmosphere and by entrainment of the air as the liquid falls back into the basin surface. Equipment suppliers report that liquid as far as 13 ft below the surface can be drawn upward to maintain a continuous mix that keeps the high concentration of activated sludge solids in suspension. The rotors would be mounted on pedestals. Due to the characteristics of the rotor aerators, the design criteria used called for a 24-hour detention period and an oxygen transfer rate of 4 lbs/hr/ft of rotor. This transfer rate is comparable to that used for the floating aerators.

As with the floating aerators described previously, an air supported cover would be installed over the activated sludge aeration basin. Similarly, a reaeration tank and clarifier with one hour and three hour detention periods, respectively, would also be installed. Operating control with this type unit would be comparable to the floating aerator system.

E. COST ESTIMATES

The cost estimates for construction and operation of each of these plants are presented in Appendices H, I, and J. Costs were based on estimating prices quoted by equipment suppliers and known construction costs for sewage treatment plants. Costs for site development, including landscaping, were included.

In preparing the cost estimates for O & M it was assumed that two full-time and one part-time operator would be needed for the plant using the compressed air diffusion system, whereas three full-time operators would be needed for the plants with mechanical aerators. Less power consumption and maintenance for the latter plants would more than offset the additional cost for plant operators, supplies, and repairs.

VII. ECONOMIC ANALYSIS

A. GENERAL

The primary purpose of this first year study was to compare the economic and technical advantages of upstream and in-sewer treatment with downstream treatment and normal sewer line operation. With pretreatment at the industrial plant source and in the sewer, the capacity of downstream treatment works can be reduced accordingly. Discharge to the sewer of activated sludge effluent with bacterial "seed" organisms allows for further biochemical stabilization in the sewer and pre-conditioning of all sewage which, in turn, can improve the downstream treatment plant efficiency. In addition, upstream treatment can help control odors and corrosion in the sewers and in the downstream treatment works. Pretreatment by activated sludge of Swift wastes will also remove some nitrogen and phosphates and provide nitrates for protecting the downstream sewer.

It may be economically feasible to reclaim additional fats and protein from Swift waste, while it is relatively concentrated and fresh. If done, this could provide additional revenue to the meat packing plant and simultaneously reduce the waste load on the Main Water Quality Plant.

It is universally recognized that preventive maintenance is more economical and operationally desirable than subsequent rectification. Both upstream and in-sewer treatment can be considered preventive maintenance measures to renovate concentrated slaughter house waste before it becomes septic, corrodes the trunk sewer, and makes downstream treatment more difficult. This principle has been applied at the Swift plant by using primary type clarifiers to separate paunch and floatables as solid waste, rather than permitting their discharge to the trunk sewer.

An economic offset to Swift for the upstream treatment is that by processing waste at the source prior to discharge to the sewer, the City of Stockton sewer service charges to Swift would be reduced.

All costs discussed herein are based on 1970 dollars except where noted otherwise, including the construction cost of existing facilities. In amortizing capital costs, a 7 percent interest rate was used throughout. The life of facilities was estimated according to reasonable engineering practices for each type of unit and is described in the cost estimate. The procedure for the economic analysis was as follows:

1. Costs were tabulated for existing construction; these were corrected to 1970 dollars excluding depreciation.

2. Budgeted operation and maintenance costs (1969-70) for existing facilities were tabulated and proportioned appropriately.

3. Construction, operation, and maintenance costs were estimated for each of the alternative facilities. Capital costs were converted to annual costs by amortizing over their useful lives (after 1970) at 7 percent interest.

Four basic alternative plans for sewerage facilities were prepared. They were subdivided as follows:

Plan A

The present practice of control treatment and no in-sewer treatment or protection.

A1. Normal sewer maintenance and 10-year sewer life.

A2. Sewer repaired as required and 20-year sewer life.

Plan B

Upstream treatment with normal sewer maintenance.

B1. Compressed air diffusion system in the upstream plant.

B2. Mechanical floating aerators in the upstream plant.

Plan C

Central treatment and in-sewer treatment.

C1. Install U-Tube stations in the sewer.

C2. Install devices in the sewer for periodic hydraulic flushing.

Plan D

Upstream treatment and in-sewer treatment.

D1. Mechanical floating aerators in the upstream plant and U-Tube stations in the sewer.

D2. Mechanical floating aerators in the upstream plant, followed by a U-Tube to aerate plant effluent, and devices in the downstream 28,000 ft of sewer to hydraulically flush the sewer.

B. CENTRAL TREATMENT

The capital costs of the Main Water Quality Plant were tabulated based on the City of Stockton Finance Department records of actual expenditures for construction for the period from 1960 to 1970 and converted to 1970 dollars by applying ENR[1] construction cost indexes for each year. The construction costs prior to 1960 were estimated in the 1965 Brown and Caldwell "Stockton Sewerage Survey" report to be $4,400,000. The ENR indexes for 1948 and 1954 were used to compute 1970 costs. For simplification and because components of the existing treatment works have been well maintained or replaced as required, these facilities were not considered as having been depreciated. Total capital cost, in 1970 dollars, was $15,567,000. (See Table VII-1.)

Operation and maintenance (O & M) of the existing facilities were computed based on the 1969-70 budget for treatment plants. From this the direct costs for operating the North Treatment Plant were subtracted. The indirect costs attributable to the Main Water Quality Plant were computed based on the proportion of O & M for the Main Water Quality Plant and the ratio of total direct cost to total indirect cost for the Sewer Division of the Department of Public Works. The total O & M for 1969-70 was calculated to be $587,000.

Within the next several years, the City of Stockton plans to construct additional facilities at the Main Water Quality Plant. These plant enlargements and modifications were outlined in the Brown and Caldwell report dated May 1969. Two conditions were presented. The first condition was for facilities to provide treatment generally comparable to that now being provided. The proposed plant additions include preliminary treatment, power generating equipment, primary and secondary treatment, coagulation/sedimentation and chlroination portions of the tertiary treatment building to house equipment, and related expenditures. The total cost of these plant additions was estimated to be $7,950,000. The second condition provides for denitrification and demineralization facilities which may be required to meet stringent wastewater discharge requirements of the Regional Water Quality Control Board. The cost of proposed denitrification facilities, which include pumping units, ammonia stripping towers, and rapid sand filters, was estimated to be $4,070,000. The total construction cost for the new facilities including denitrification was estimated at $12,020,000. The costs for demineralization facilities was not included in this analysis because upstream treatment and sewer control would not significantly affect the concentration of total dissolved solids of the wastewater.

The decision on constructing denitrification and demineralization works is dependent upon the quantity of diluting water available in the San Joaquin River to maintain nitrogen and total dissolved solid levels in the receiving waters within the specified limits of 3.0 and 500 mg/l, respectively. Engineering studies are being made of the California Water Project, the Central Valley Project, and other local upstream uses effects on quantity, quality, and seasonal distribution of water flowing through the Delta from the Sacramento and San Joaquin Rivers.

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[1] Engineering News Record.

TABLE VII-1

MAIN WATER QUALITY CONTROL PLANT COSTS
(1970 Dollars Except as Noted)

Construction, Excluding Land Costs				
Fiscal Year	Actual[1] Cost ($)		ENR Cost[2] Indices	Amount ($1000)
1969 - 70	13,353	x	1300/1300	13
1968 - 69	256,453	x	1300/1201	278
1967 - 68	278,927	x	1300/1098	330
1966 - 67	50,435	x	1300/1034	63
1965 - 66	17,602	x	1300/988	23
1964 - 65	481,888	x	1300/948	661
1963 - 64	1,484,335	x	1300/915	2,109
1962 - 63	126,063	x	1300/880	186
1961 - 62	111,440	x	1300/855	169
1960 - 61	39,682	x	1300/831	62
1948 - 60	1,400,000[3]	x	1300/643[4]	2,830
1946 - 48	3,000,000[3]	x	1300/441[5]	8,843
	7,260,178		Total	15,567
Plant Additions - 5 Year Program[6]				
Preliminary Treatment			350	
Power Generating Equipment			135	
Primary Treatment			900	
Secondary Treatment			3,175	
Miscellaneous			235	
	Subtotal		4,795	
Tertiary Treatment				
Coagulation/Sedimentation			1,360	
Chlorination			185	
	Subtotal		6,340	
Contingencies, 15%			950	
	Subtotal		7,290	
Engineering, 9%			660	
	Total, Assuming Denitrification and Demineralization Facilities Not Required			7,950

TABLE VII-1 (Continued)

MAIN WATER QUALITY CONTROL PLANT COSTS
(1970 Dollars Except as Noted)

Construction (Continued)		Amount ($1000)
Tertiary Treatment for Denitrification[7]		
Pumping Units	200	
Ammonia Stripping Towers	780	
Rapid Sand Filters	2,260	
Subtotal	3,240	
Contingencies, 15%	490	
Subtotal	3,730	
Engineering, 9%	340	
Total for Denitrification		4,070
Total Construction Cost[7]		
Without Denitrification		23,517
With Denitrification		27,587
Amortized Replacement Cost[7]		
30 Year Life and 7% Interest (0.08059 factor)		
Plant Without Denitrification		1,895
Plant With Denitrification		2,223
Operation and Maintenance		
1969 - 70 Budget for Main and North Treatment Plants		569
1969 - 70 Budget for North Treatment Plant		33
1969 - 70 Budget for Main Treatment Plant		536
Administrative and General Costs Attributable to Main Treatment Plant, $32,970 x 0.64[8]		21
Customers Accounts Cost Attributable to Main Treatment Plant, $47,041 x 0.64[8]		30
Subtotal		587

TABLE VII-1 (Continued)

MAIN WATER QUALITY CONTROL PLANT COSTS
(1970 Dollars Except as Noted)

Operation and Maintenance (Continued)	Amount ($1000)
Estimated for Additional Facilities Without Denitrification	
$\$587{,}000\ \left(\frac{\$\ 7{,}950{,}000}{\$15{,}567{,}000}\right)1/2$	150
Estimated for Additional Facilities With Denitrification	
$\$587{,}000\ \left(\frac{\$12{,}020{,}000}{\$15{,}567{,}000}\right)1/2$	227
Totals	
Without Denitrification	737
With Denitrification	814
Attributed to Swift and Company Discharges	
Without Denitrification	52
With Denitrification	57
Total Annual Costs	
Without Denitrification	2,632
With Denitrification	3,037

[1] Approximate, from City records.

[2] For January of each Fiscal Year.

[3] From Brown and Caldwell's Stockton Sewerage Survey dated February 1965.

[4] For January 1954.

[5] For January 1948.

[6] From Brown and Caldwell report on plant enlargement and expansion dated May 1969.

[7] Cost of demineralization facilities not included because upstream treatment plant would not significantly affect the TDS.

[8] Percentage computed on the proportion of Main Water Quality Control Plant budget to total Sewer Division budget less indirect costs.

O & M cost for future facilities at the Main Water Quality Plant was estimated as follows:

$$0.50 \times \frac{\text{Construction costs of future facilities}}{\text{Capital cost of existing facilities in 1970 Dollars}} \times \text{1969-70 O \& M Budget}$$

The total estimated O & M costs of both existing and future facilities with and without denitrification facilities were $814,000 and $737,000, respectively. These costs exclude provision for demineralization facilities.

The total annual costs for the Main Treatment Plant without and with denitrification facilities were $2,632,000 and $3,037,000, respectively. These annual costs include amortization of capital costs, O & M, administrative, and overhead.

The proportion of these capital, O & M, and annual costs attributed to treatment of Swift discharges were computed as the ratio of BOD discharged from the Swift plant (1.5 mgd, 1200 mg/l BOD, 5 days/wk) to BOD received at the treatment plant in 1973-74, corrected for size. For year-round operation, 11 percent of the total BOD loading of the Main Water Quality Plant is from Swift. Based on general curves relating cost of treatment works and operation and maintenance to wasteload, and in-situ conditions, it was estimated that 7 percent (11 percent x size factor of 5/8) of the cost of downstream treatment was attributed to Swift discharges.

The capital costs (1970) attributed to Swift discharges were computed as $1,646,000 and $1,931,000 without and with denitrification facilities. Annual costs attributed to Swift were $184,000 and $213,000, without and with denitrification.

C. UPSTREAM TREATMENT

Three alternative high rate activated sludge plants were considered. Each would use the basic principles of the Kehr process for operation.

The proposed Swift demonstration treatment plant would be constructed upstream of the Parshall flume on about one to two acres, located at the westerly portion of the Swift property. Trees and other landscaping should be provided to improve the overall appearance of the works. Construction costs for each plant were estimated based on equipment prices provided by equipment suppliers and known basic construction costs for tanks and appurtenances. These estimates are presented in Appendices H, I, and J, as are the estimated annual costs which include amortized capital, maintenance, supervision, overhead and contingencies. Costs are shown two ways: first, the total capital cost is shown, and the entire capital cost is amortized; in the second case, which is shown in parenthesis, only that portion of the cost that would be paid by the City is amortized. Forty-six percent of the construction costs would be paid from Federal Water Pollution Control Administration (F.W.P.C.A.) Grant No. 11060 DRT.

Costs for each method were estimated as follows:

1.	Compressed Air Diffusion System:	Capital costs -	$621,300 (355,500)
		Annual costs -	$133,200 (106,300)
2.	Mechanical Floating Aerators:	Capital costs -	$438,400 (236,700)
		Annual costs -	$113,200 (94,100)
3.	Mechanical Brush Aerators:	Capital costs -	$499,400 (270,000)
		Annual costs -	$120,100 (98,500)

The estimated cost for the compressed air diffusion system exceeds the eligible project costs for which Federal matching grants are available by $112,000; $29,000 is for engineering which could be covered by other portions of the Grant. The remainder is for contingencies which the F.W.P.C.A. did not allow as eligible project costs. If this alternative is selected for construction, a supplemental grant application should be submitted as soon as possible to cover contingencies.

Estimated capital costs for the other treatment methods are within the F.W.P.C.A. grant budget.

D. SOUTHERN INDUSTRIAL SANITARY TRUNK SEWER

1. General

The Southern Industrial Trunk extends approximately 8 miles from Swift to the Main Water Quality Plant. It consists of 48, 42, and 30 in. reinforced concrete pipe. The bulk of the sewer line was constructed in Fiscal Year 1959-60 at a cost of $1,013,000. (See Table VII-2.) This cost was based on records of the City of Stockton Finance Department and an estimated $33,000 for the 1,313 ft length of 42-in. RCP which existed in 1959. Based on the ENR construction cost indexes in 1970 and 1960, replacement cost for the sewer line would be $1,630,000.

Normally a trunk sewer would be expected to have a life of 30 or more years. However, as described in Chapter III, a considerably shorter life should be anticipated. The estimated sewer lives under various conditions were predicted in Chapter III.

TABLE VII-2

SOUTHERN INDUSTRIAL SANITARY TRUNK SEWER COSTS
(1970 Dollars Except as Noted)

Construction		Amount ($1000)
1959 - 60 48" R.C.P. - 10,509 ft 42" R.C.P. - 16,611 ft 30" R.C.P. - 11,916 ft		
Subtotal - 1960 Cost	980	
Prior to 1959 42" R.C.P. - 1,314		
Estimated - 1960 Cost	33	
Subtotal - 1960 Dollars	1,013	
1970 Dollars[1]		1,630
Amortized Replacement Cost (7% Interest)		
10 yr Life (0.14238 factor)		232
20 yr Life (0.09439 factor)		154
25 yr Life (0.08581 factor)		140
30 yr Life (0.08059 factor)		131
Operation and Maintenance		
1969 - 70 Budget for City Sewer Maintenance	243	
Administrative and General Costs Attributable to Sewer Maintenance, $32,970 x 0.27[2]	9	
Customers Accounts Costs Attributable to Sewer Maintenance, $47,041 x 0.27[2]	13	
Subtotal	265	
Proportion Attributable to Normal Maintenance of the Southern Industrial Sanitary Trunk:[3] $265,000 x 0.06[4]		16
Normal Maintenance and Repairs[5]		32

TABLE VII-2 (Continued)

SOUTHERN INDUSTRIAL SANITARY TRUNK SEWER COSTS
(1970 Dollars Except as Noted)

Total Estimated Annual Cost	Amount ($1000)
10 yr Life, Normal Maintenance	248
20 yr Life, Normal Maintenance and Repairs	186
20 yr Life, Normal Maintenance	170
25 yr Life, Normal Maintenance	156
25 yr Life, Normal Maintenance and Repairs	172
30 yr Life, Normal Maintenance	147

[1] Based on ENR Construction Cost Index of 1300 for January 1, 1970, and 808 for 1960, and estimated replacement costs.

[2] Percentage computed on the proportion of sewer maintenance to total Sewer Division budget less indirect costs.

[3] Existing normal maintenance.

[4] Computed as follows: $\frac{\text{Length of Trunk Sewer}}{\text{Total Length of City Sewers}}$

x Weighting Factor of 2 for Large Diameter Trunk.

[5] Special efforts needed for frequent repairs in order to keep the sewer in service without in-sewer treatment such as aeration, chemical additives, or flushing.

The costs for normal operation and maintenance of the trunk sewer were estimated based on the City of Stockton 1969-70 budget for sewer maintenance plus the proportion of administrative, general, and customer account services attributable to sewer maintenance. The total 1969-70 costs were $265,000. The proportion attributable to routine maintenance of the Southern Industrial Trunk were estimated to be 6 percent of the total or $16,000 per year. The 6 percent was computed as follows:

$$\frac{\text{8 mi length of trunk sewer}}{\text{270 mi length of sewer maintained by City}} \times \text{(size factor of 2 due to large diameter)}$$

To extend the life of the sewer to 20 years periodic major repairs also would be needed. The cost of major repairs was estimated to be $16,000 per year, the total cost for maintenance and repairs was estimated to be $32,000 per year.

Total estimated annual costs for alternative sewer lives and maintenance and repair programs are presented in Table VII-2. These range from $248,000 per year for a sewer life of 10 years and normal maintenance to $147,000 per year for a 30-year sewer life, in-sewer treatment and upstream treatment.

2. Sewer Lining

Table VII-3 is a tabulation of the cost for installing a "Techite" liner. Based on a cost of $1.00/in. of liner diameter/LF, the lining would cost approximately $1,500,000. It would not have to be installed until sacrificial concrete of the existing pipe was lost. Upstream sections of the sewer, if in relatively good condition, would not require lining, reducing this capital expenditure. For this analysis, it was assumed that the existing pipe could be used for another 10 years, and then the entire 40,340 ft length of sewer would be lined with Techite pipe. Total annual cost, including maintenance and amortization, from 1970 to 1980, prior to lining, was estimated to be $147,000; after lining, from 1980 to 2000, the annual cost was estimated to be $288,000.

3. Sewer In-line Treatment Methods

Various methods were studied for in-line treatment and protection of the sewer against rapid corrosion; these methods included addition of chemicals; aeration (oxygenation); and periodic flushing of the sewers.

Oxidizing chemicals considered for application to the sewer were hydrogen peroxide, chlorine, and sodium nitrate. Other chemical oxidants, such as potassium permanganate, are known from waterworks experience to be too costly to warrant serious consideration. The activated sludge waste from an upstream treatment plant contains a high nitrate concentration. This also is an attractive in-line sewer treatment possibility. Other studies have indicated that annual costs for addition of chlorine, sodium

TABLE VII-3

SOUTHERN INDUSTRIAL SANITARY TRUNK SEWER COSTS USING AN INERT LINER

Construction	Amount ($1000)
Original R.C.P. - 1960 Dollars	1,013
1970 Dollars	1,630
Lining with Inert Liner[1]	
48" Pipe, 10,509 ft @ $45/lin ft	473
42" Pipe, 17,915 ft @ $39/lin ft	699
30" Pipe, 11,916 ft @ $27/lin ft	322
Subtotal[2]	1,494
Amortized Capital Cost (7% Interest)	
30 yr Life for R.C.P. (1970-2000)	
0.08059 x $1,630,000	131
20 yr Life for Liner (1980-2000)	
0.09439 x $1,494,000	141
Maintenance Cost (Normal)	16
Total Estimated Annual Costs	
1970 - 80	147
1980 - 2000	288

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[1] Based on a cost of $1.00/lin ft of diameter, including engineering and contingencies, 1970 Dollars.

[2] Entire 40,340 ft length of sewer to be lined in 1980.

nitrate and hydrogen peroxide were about $5,000, $3,000, and $5,000 per mgd, respectively.

Hydrogen peroxide addition to raw Swift wastewater was not economically and technically feasible. When preceded by aeration, hydrogen peroxide was effective on pilot test samples in oxidizing and preventing reformation of sulfides in the Swift wastewater.

Design criteria and cost estimates (Appendix E) were developed for applying hydrogen peroxide at three feed stations to protect the entire 40,340 ft length of trunk sewer, following treatment at the upstream activated sludge plant. A sulfide free sewage should extend the life of the trunk sewer to at least 30 years with normal maintenance.

The cost for constructing three stations for applying hydrogen peroxide was estimated at $70,400. Estimated annual cost including chemicals, labor, power, and amortization of capital costs was $26,900 per year based on existing flows. Using Federal grant monies to construct these facilities would reduce the City's capital expenditure to $38,000 and annual costs to $23,900.

Some information is available on the use of alkaline chemicals and precipitating salts for sulfide control. The cost for addition of lime or caustic soda was estimated to range from $2,000 to $4,500/mgd/yr. Calculations were also made for application of iron, lead, and zinc salts to control sulfides. The economics of their usage depend on their availability as a waste product at little or no cost. None of these metallic salts appear feasible for use in the Stockton demonstration.

Two methods of applying compressed air to sewers were considered. In the first, air piping would be installed in the gravity sewer and compressed air diffused into the sewage to increase the dissolved oxygen content. Preliminary cost estimates for this method of protection indicated that the construction and operation costs were much higher than other available alternative protective methods.

A more promising method of aerating sewage would be by U-Tube installation. Two cases were considered, one with an upstream treatment plant at Swift, and the other without an upstream activated sludge treatment plant. Construction and operation of six U-Tube stations without upstream treatment were estimated to extend the life of the sewer to 20 years with normal maintenance, and up to 30 years with major repairs. Construction of five U-Tube stations following upstream treatment, was estimated to extend the sewer life to 30 years.

Construction costs for five U-Tube stations following upstream treatment were estimated at $127,800. For six stations, without upstream treatment, construction costs were estimated at $159,500. Excluding the Federal grant monies, the City's capital expenditures would be $69,000 and $86,100, respectively. The detailed cost estimates are shown in Appendix F, together with the estimated annual cost breakdown. The annual cost for five U-Tube stations, including amortization at 7 percent interest and a 20-year life, maintenance, supervision, overhead, and contingencies was $22,400. For six U-Tube stations the annual cost was estimated at $30,500. Excluding Federal grant monies, the annual costs would be $16,000 and $23,600, respectively.

A third alternative method for protection from sulfide attack would be by hydraulically flushing the sewer. This can be accomplished by installing inflatable dams in the sewer line.

The cost to construct 10 inflatable dams, two in the 10,509 ft length of 48 in. sewer, three in the 17,925 ft length of 42 in. sewer, and five in the 11,916 ft length of 30 in. sewer, was estimated at $88,200. (See Appendix G.) The annual cost including amortization at 7 percent interest, a 20-year life, maintenance, supervision, overhead, and contingencies was estimated at $16,000. Excluding Federal grant monies, capital expenditures and annual costs would be $47,600 and $12,200, respectively.

E. SEWER SERVICE CHARGES

The City of Stockton desires to operate their sewerage system on a pay-as-you-go basis by levying monthly charges on all connections. Individual home-owners, commercial and industrial users with small waste discharges are charged specified amounts each month. Sewer service charges to industries with large flows are based on volume of wastewater, BOD strength, and sewerage system availability. Charges levied on Swift and Company in 1969 are presented in Table VII-4. The 1969 charge of $21,395 to Swift was based on the following items:

BOD	$ 8,523
Quantity	9,452
Availability	3,420

With a treatment plant at Swift, the annual savings to Swift in reduced sewer service charges would have been $8,523.

If Swift goes on a two-shift operation, wastewater discharges would average 1.5 mgd, and BOD would average 1200 mg/l. The estimated sewer service charges, based on the current rate schedule, would be $31,300. (See Appendix C.) This would be based on the following items:

BOD	$ 15,440
Quantity	12,440
Availability	3,420

With a treatment plant at Swift, the annual savings to Swift in reduced sewer charges

TABLE VII-4

CITY MONTHLY SEWER SERVICE CHARGE
TO SWIFT AND COMPANY

	Wastewater		Monthly Charges ($)			Annual Demand Charge[1]		
Month	Volume (MG)	BOD (1000 lb)	Volume	BOD	Customer	Volume	BOD	Total ($)
(1969)								
Jan.	16.57	114	365	299	285	137[2]	61[2]	1,147
Feb.	23.44	190	516	568	285	137	61	1,567
Mar.	31.63	262	696	793	285	137	61	1,972
Apr.	22.58	141	497	333	285	137	61	1,313
May	22.61	216	585	644	285	137	61	1,712
June	19.19	142	422	394	285	137	61	1,299
Adjust[3]						620	486	1,106
July	20.23	146	445	399	285	261[4]	141	1,531
Aug.	23.12	199	509	617	285	261	141	1,813
Sept.	22.63	194	498	598	285	261	141	1,783
Oct.	25.88	229	569	723	285	261	142	1,980
Nov.	32.20	240	708	671	285	261	141	2,067
Dec.	28.80	251	634	784	285	261	141	2,105
Total	288.88	2,324	6,444	6,823	3,420	3,008	1,700	21,395

[1] Billed monthly. Normally computed on the basis of the maximum month discharge.

[2] Charges based on January 1969 discharge.

[3] Adjusted based on maximum month discharge.

[4] Based on maximum month discharge. (March 1969.)

would be approximately $15,400.

The City is considering an increase in sewer service charges. No decisions have been made on this matter to date. For this estimate, the following rates were assumed:

Monthly Charges

Volume	$44/MG
BOD	$7/1,000 lb BOD
Customer Service	$400/month

Annual Demand Charge (Availability)

Volume	$200/MG in the maximum month
BOD	$10/MG in the maximum month

Using these assumed rates, wastewater discharges averaging 1.5 MGD, and BOD concentrations of 1,200 mg/l, potential sewer service charges were computed (see Appendix C). The total of $60,600 was based on the following items:

BOD	$ 30,720
Quantity	25,080
Availability	4,800

If a treatment plant at Swift provided 90 percent BOD reduction, the annual savings to Swift in reduced sewer charges would be about $27,600.

If the upstream treatment plant were constructed and operated by the City, it would be reasonable to expect Swift to contribute their reduced sewer service charge toward construction and/or operation of the facility. The specific dollar amount would, of course, be subject to negotiation.

F. SUMMARY

Table VII-5 summarizes the cost in 1970 dollars for the above-described existing and proposed alternative sewerage facilities.

From the cost summary tabulation and the detailed estimates appended, Table VII-6 was prepared to compare costs of more promising alternative plans. In Section A above, the concepts for each of the plans were described. For each plan, the costs for central treatment at the Main Water Quality Plant, in-sewer, and upstream treatment were included.

Tables VII-5 and VII-6 were prepared to show capital expenditures and annual costs

TABLE VII-5

COST SUMMARY
(1970 Dollars Except as Noted)

Description	Amount ($1000)
Main Water Quality Control Plant	
Capital Costs	
Construction Cost - 1970 Dollars	15,567
5 yr Plant Additions Without Denitrification[1]	7,950
5 yr Plant Additions for Denitrification[1]	4,070
Total Without Denitrification	23,517
Total With Denitrification	27,587
Capital Costs Attributed to Swift and Company Discharges[2]	
Without Denitrification	1,646
With Denitrification	1,931
Annual Costs[3]	
Without Denitrification	2,632
With Denitrification	3,037
Annual Costs Attributed to Swift and Company Discharges	
Without Denitrification	184
With Denitrification	213
Upstream Activated Sludge Treatment Plant	
Compressed Air Diffusion System	
Capital Cost	621 (336)[4]
Annual Cost	133 (106)
Mechanical Floating Aerators	
Capital Cost	438 (237)
Annual Cost	113 (94)
Mechanical Brush Aerators	
Capital Cost	499 (270)
Annual Cost	120 (99)

TABLE VII-5 (Continued)

COST SUMMARY
(1970 Dollars Except as Noted)

Description	Amount ($1000)
Southern Industrial Sanitary Trunk Sewer	
Construction Cost - 1960 Dollars	1,013
1970 Dollars	1,630
Annual Cost, 10 yr Life[5]	248
20 yr Life	170
25 yr Life	156
30 yr Life	147
Southern Industrial Sanitary Trunk Sewer With Inert Liner	
Construction Cost, Pipe	1,630
Liner	1,494
Annual Cost, 1970 - 1980	131
1980 - 2000	272
Sewer Protection	
Hydrogen Peroxide Application, Following Upstream Treatment	
Capital Cost	70 (38)
Annual Cost	27 (24)
U-Tube Installation	
With Upstream Treatment	
Capital Cost	128 (69)
Annual Cost	22 (17)
Without Upstream Treatment	
Capital Cost	160 (86)
Annual Cost	31 (24)
Hydraulic Flushing	
Capital Cost	88 (48)
Annual Cost	16 (12)

TABLE VII-5 (Continued)

COST SUMMARY
(1970 Dollars Except as Noted)

Description	Amount ($1000)
City Sewer Service Charges for Swift and Company	
1969, Based on Actual Discharges and Charges	21
With an Upstream Treatment Plant	13
Future, Based on 1.5 MGD Average Discharge, Existing Rate Schedule, and Without Upstream Treatment	31
With an Upstream Treatment Plant	16
Future, Based on 1.5 MGD Average Discharge, Increased Rate Schedule, and Without Upstream Treatment	61
With an Upstream Treatment Plant	33

[1] Excludes costs of demineralization because upstream treatment will not significantly affect TDS.

[2] Based on proportion of BOD generated by Swift and Company to total projected 1973 - 74 BOD loading at the treatment plant, weighted for year-round flow and corrected for size (7% of capital cost).

[3] Includes amortization of capital expenditures at 7%, maintenance, overhead, and administration.

[4] Bracketed amounts exclude Federal Grant monies.

[5] With normal maintenance.

TABLE VII-6

COST COMPARISON
(1970 Dollars)

Plan Designation	Description	Costs ($1,000)						
		Capital Expenditures			Operation and Maintenance			
		Completed	To Be Constructed	Total	Existing	Additional	Total	Annual
A1	Continue present practice of central treatment and no in-sewer treatment:							
	1. Expand central plant on proposed 5-yr plan (30-yr life).	15,567	12,020	27,587	587	227	814	3,037
	2. Sewer Life - 10 yrs.	1,630	--	1,630	16	--	16	248
	Subtotals	17,197	12,020	29,217	603	227	830	3,285
A2	Continue present practice of central treatment and no in-sewer treatment:							
	1. Expand central plant per proposed 5-yr plan (30-yr life).	15,567	12,020	27,587	587	227	814	3,037
	2. Normal maintenance and major repairs on sewer (20-yr life).	1,630	--	1,630	16	16	32	186
	Subtotals	17,197	12,020	29,217	603	243	846	3,223
B1	Upstream treatment with no in-sewer treatment:							
	1. Expand central plant per 5-yr plan less 90% of Swift's loading (30-yr life).	15,567	10,282	25,849	587	201	788	2,871

TABLE VII-6 (Continued)

COST COMPARISON
(1970 Dollars)

Plan Designation	Description	Costs ($1,000)						
		Capital Expenditures			Operation and Maintenance			Annual
		Completed	To Be Constructed	Total	Existing	Additional	Total	
B1 (Cont.)	2. Construct upstream treatment plant using compressed air diffusion system (20-yr life).	--	621 (336)[1]	621 (336)	--	75	75	133 (106)
	3. Sewer Life - 20 yrs.	1,630	--	1,630	16	--	16	170
	Subtotals	17,197	10,903 (10,618)	28,100 (27,815)	603	276	879	3,174 (3,147)
B2	Upstream treatment with no in-sewer treatment:							
	1. Expand central plant per 5-yr plan less 90% of Swift's BOD loading (30-yr life).	15,567	10,282	25,849	587	201	788	2,871
	2. Construct upstream treatment plant using mechanical floating aerators (20-yr life).	--	438 (237)	438 (237)	—	72	72	113 (94)
	3. Sewer Life - 20 yrs.	1,630	--	1,630	16	--	16	170
	Subtotals	17,197	10,720 (10,519)	27,917 (27,716)	603	273	876	3,154 (3,135)

TABLE VII-6 (Continued)

COST COMPARISON
(1970 Dollars)

Plan Designation	Description	Costs ($1,000)						
		Capital Expenditures			Operation and Maintenance			Annual
		Completed	To Be Constructed	Total	Existing	Additional	Total	
C1	Central treatment and in-sewer treatment:							
	1. Expand central plant per proposed 5-yr plan (30-yr life).	15,567	12,020	27,587	587	227	814	3,037
	2. Construct 6 U-Tube stations (20-yr life).	--	160 (86)	160 (86)	--	16	16	31 (24)
	3. Sewer Life - 25 yrs.	1,630	--	1,630	16	--	16	156
	Subtotals	17,197	12,180 (12,106)	29,377 (29,303)	603	243	846	3,224 (3,217)
C2	Upstream treatment and in-sewer treatment:							
	1. Expand central plant per proposed 5-yr plan (30-yr life).	15,567	12,020	27,587	587	227	814	3,037
	2. Construct 10 Fabridams (20-yr life).	--	88 (48)	88 (48)	--	10	10	16 (12)
	3. Sewer Life - 25 yrs.	1,630	--	1,630	16	--	16	156
	Subtotals	17,197	12,108 (12,068)	29,305 (29,265)	603	237	840	3,209 (3,205)

TABLE VII-6 (Continued)

COST COMPARISON
(1970 Dollars)

Plan Designation	Description	Costs ($1,000)						
		Capital Expenditures			Operation and Maintenance			Annual
		Completed	To Be Constructed	Total	Existing	Additional	Total	
D1	Upstream treatment and in-sewer treatment:							
	1. Expand central plant per 5-yr plan less 90% of Swift's loading (30-yr life).	15,567	10,282	25,849	587	201	788	2,871
	2. Construct upstream treatment plant using mechanical floating aerators (20-yr life).	—	438 (237)	438 (237)	--	72	72	113 (94)
	3. Construct 5 U-Tube stations (20-yr life).	--	128 (69)	128 (69)	--	10	10	22 (17)
	4. Sewer Life - 30 yrs.	1,630	—	1,630	16	--	16	147
	Subtotals	17,197	10,848 (10,588)	28,045 (27,785)	603	283	886	3,153 (3,129)
D2	Upstream treatment and in-sewer treatment:							
	1. Expand central plant per 5-yr plan less 90% of Swift's loading (30-yr life).	15,567	10,282	25,849	587	201	788	2,871

TABLE VII-6 (Continued)

COST COMPARISON
(1970 Dollars)

Plan Designation	Description	Costs ($1,000)						
		Capital Expenditures			Operation and Maintenance			
		Completed	To Be Constructed	Total	Existing	Additional	Total	Annual
D2 (Cont.)	2. Construct upstream treatment plant using mechanical floating aerators	—	438 (237)	438 (237)	—	72	72	113 (94)
	3. Construct one U-Tube station at upstream treatment plant	—	11 (6)	11 (6)	—	2	2	4 (3)
	4. Construct 5 Fabridams in sewer.	—	47 (24)	47 (24)	—	4	4	9 (7)
	5. Sewer Life - 30 yrs.	1,630	—	1,630	16	—	16	147
	Subtotals	17,197	10,778 (10,549)	27,975 (27,746)	603	279	882	3,144 (3,122)

---

[1] Bracketed figures exclude Federal Grant funds.

with and without Federal funds from Grant No. 11060-DRT. The unbracketed figures are total costs and the bracketed figures exclude capital expenditures and amortization of Federal funds. For simplification and because the grant already has been made to the City, the following discussion is limited to the case where Federal funds are excluded; i.e., the bracketed figures.

These cost comparisons were prepared assuming that denitrification facilities would be required. Upstream treatment of Swift wastewater would significantly reduce the total nitrogen level at the downstream central plant. It is possible that the reduced nitrogen content may simplify future denitrification requirements. Reduction of denitrification facilities at the Main Water Quality Plant could reduce capital construction expenditures by as much as $4 million and reduce plant O & M costs by as much as $75,000 per year.

The four plans that include an upstream treatment plant at Swift are the least costly, from the standpoint of both total annual operating cost and capital expenditures. The most economical plan, based on total annual cost, is Plan D2 which consists of upstream treatment using mechanical floating aerators to reduce Swift wastewater BOD by 90 percent, one U-Tube station immediately downstream of the plant at Swift, and five Fabridams in the sewer. The annual cost of this plan was estimated to be $3,122,000. Estimated O & M cost in excess of the current budget was $279,000 per year.

For all practical purposes, Plans B2 and D1 have the same annual costs: $3,135,000 and $3,129,000, respectively. Both plans include an upstream treatment plant using mechanical floating aerators. Plan B2 has no in-sewer treatment and Plan D1 includes five U-Tube stations in the trunk sewer. Capital expenditures to implement Plan B2 are the least of any system: $10,579,000; compared to $10,588,000 for Plan D1. Operation and maintenance for Plans B2 and D1 in excess of the current budget were estimated at $273,000 and $283,000 per year, respectively.

Plan B1 which consists of upstream treatment using a compressed air diffusion system had an estimated annual cost of $3,147,000; a capital expenditure of $10,618,000 and O & M cost in excess of the current budget of $276,000 per year.

The total annual costs for Plans A1, A2, C1, and C2, none of which include upstream treatment, were $3,285,000, $3,223,000, $3,217,000, and $3,205,000, respectively, or about 2 percent more than with upstream treatment. Each of these plans requires a capital expenditure for construction in excess of $12,000,000, compared to capital expenditures of less than $11,000,000 with upstream treatment.

An upstream treatment plant is highly desirable from a technical and cost standpoint. It treats the Swift wasteload at the point of origin before dilution and allows further in-sewer nitrates and activated sludge treatment. The upstream treatment facilities are relatively simple, compared to those needed at the Main Water Quality Plant. With upstream treatment, loadings on the Main Water Quality Plant will be reduced, thereby reducing odor problems and the capacity of future facilities.

Considering only the Southern Industrial Trunk, without upstream treatment, it is economically desirable to provide in-sewer treatment to extend the life of the sewer and to condition the sewage. Plan C2, which consists of installation of Fabridams to hydraulically flush the sewer, is the most economical from the standpoint of annual cost: $168,000 per year. This compares with Plan C1 which consists of U-Tube aeration of the sewer, with an annual cost of $180,000. Capital costs of Plans C1 and C2 are $85,000 and $48,000, respectively.

Plans A1 and A2, which have no capital expenditures for in-sewer treatment, have annual costs estimated at $248,000 and $186,000, respectively.

The construction cost for the recommended upstream and in-sewer treatment works (Plan D2) was estimated at $496,000. These costs would be eligible project costs under Grant No. 11060 DRT, with the Federal Water Pollution Control Administration providing $234,100. O & M for the upstream and in-sewer treatment works was estimated at $78,000 per year.

Following is a tabulation of costs for continuing present practices vs. implementation of recommended Plan D2. Costs for Plan D2 exclude Federal Grant funds.

COST COMPARISON

Plan		Costs ($1000)	
No.	Description	Construction	Annual
A2	Swift portion of central plant and sewer costs	1,838	352
D2	Upstream and in-sewer treatment costs	267	251
	Savings to the City of Stockton	1,571	101

ACKNOWLEDGMENTS

We gratefully acknowledge the support of the cognizant authorities in the Federal Water Pollution Control Administration, the City of Stockton, California, and Swift and Company.

We are especially indebted to: Mr. Thomas Dosh, Director of Public Works, and Mr. Arthur Vieira, Utilities Division Superintendent for the City of Stockton; Mr. James Robertson, Project Officer, who has been the technical representative for the Federal Water Pollution Control Administration; and Mr. B. A. Balgus, General Manager, and Mr. L. W. Overstreet, Plant Superintendent for Swift and Company. Under their direction the City of Stockton and Swift and Company have provided personnel, equipment and related support facilities for the conduct of the field demonstration work program.

Mr. Walter Witz, Utilities Division Assistant Superintendent; Mr. Arnold Hoffman, Chemist; and Mr. Jim Foster, Industrial Waste Inspector; directed the City of Stockton's comprehensive day-by-day efforts. Mr. Charles Fultz, Chief Engineer, directed the long-term plant data gathering work for Swift and Company.

FMC Corporation staff members: Mr. John Shepherd, Project Engineer; Mr. Milton Spiegel, Consultant; and Mr. Floyd Hobbs, Senior Chemist provided technical assistance concerning the Kehr process and in-sewer hydrogen peroxide treatment.

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APPENDIX A

RESOLUTION
CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD
WASTE DISCHARGE REQUIREMENTS
For The
CITY OF STOCKTON
MAIN WATER QUALITY CONTROL PLANT
San Joaquin County

Resolution No. 69-200 Adopted: 2/14/69

WHEREAS, the City of Stockton treats municipal and industrial wastes in a treatment works located on the San Joaquin River; and

WHEREAS, the nature of discharges from these facilities has been governed by Resolution No. 106 (51-85) adopted by the Central Valley Regional Water Quality Control Board on 7 November 1951; and

WHEREAS, treated wastes from the Stockton main plant are discharged to the San Joaquin River, or to Burns cut-off which is tributary to the San Joaquin River on either end; and

WHEREAS, the San Joaquin River and tributary channels in this area are a part of the Delta waters as defined in the "Water Quality Control Policy for the Sacramento-San Joaquin Delta" (Delta Water Quality Control Policy) as adopted by the State Water Quality Control Board (now State Water Resources Control Board); and

WHEREAS, beneficial uses of these waters, as identified in the aforesaid policy are: domestic and municipal supply; agricultural and industrial supply; propagation, migration, sustenance and harvest of fish, aquatic life and wildlife; recreation; esthetic enjoyment; navigation; and waste disposal, assimilation and transport. In the Stockton area, recreation uses include boating, yachting, skiing and swimming; and

WHEREAS, the aforementioned policy prescribes a set of water quality objectives for these waters; and

WHEREAS, it is the intent of the Central Valley Regional Water Quality Control Board to preserve the quality of the San Joaquin River and other Delta waters within the limits prescribed by the Delta Water Quality Control Policy; and

WHEREAS, it is further the intent of the Central Valley Regional Water Quality Control Board to so regulate waste discharges into these waters including the discharge from the City of Stockton Main Water Quality Control Plant so as to conform to the

Delta Water Quality Control Policy; therefore be it

RESOLVED, that the following requirements shall govern the nature of any waste discharge from the Stockton Main Water Quality Control Plant:

1. Any of the plant effluent, reaching surface waters of the area, by any means whatsoever, shall:

   A. Be adequately disinfected and in no case shall cause the receiving waters to exceed a median fecal coliform level of 200/100 ml.

   B. Not cause the dissolved oxygen content of the receiving waters to fall below 5.0 mg/l at any time.

   C. Not cause the total nitrogen content of receiving waters to exceed 3.0 mg/l.

   D. Not cause concentrations of materials in the receiving waters which are deleterious to human, plant or aquatic life.

   E. Not contain recognizable solids of sewage or waste origin.

   F. Not cause fungus growths in the receiving waters or on stream banks.

   G. Not cause objectionable concentrations of floating or emulsified grease or oil in Delta waters.

   H. Not cause detectable taste or odor in any public water supply.

   I. Not cause sludge deposits in the receiving waters.

   J. Not cause objectionable color in the receiving waters.

   K. Not cause the mean monthly total dissolved solids (TDS) of receiving waters to increase above 500 mg/l, as measured on the basis of the average mean daily values for any calendar month.

   L. Not cause the biocide content, as determined by the summation of individual concentrations, to increase above 0.6 ug/l; nor shall the concentrations of individual or combinations of pesticides in the Delta waters, as a result of this discharge, reach those levels found to be detrimental to fish or wildlife.

   M. Not cause the pH of receiving waters to fall below 6.5; nor to exceed 8.5.

2. Neither the waste discharge nor the method of disposal shall cause a public nuisance by reason of odors or unsightliness.

3. Waste discharge shall not cause a pollution of usable ground or surface waters.

RESOLVED, further, that because of the time-lag inherent in public works construction, the City of Stockton is hereby granted a period of not to exceed five years from the date of adoption of this resolution to bring its waste discharge into full compliance with the requirements prescribed herein, excepting that the City of Stockton will be held fully accountable for complying with the requirements of Resolution No. 51-85 which shall also remain in effect to govern the waste discharges from the City of Stockton throughout the aforementioned five year interim period; and be it

RESOLVED, further, that the City of Stockton shall submit quarterly progress reports demonstrating that activities and construction for achieving compliance with these requirements in five years is under way and on schedule; and be it

RESOLVED, further, that the discharger shall report promptly to the Central Valley Regional Water Quality Control Board any future changes in the waste discharge or changes in the conditions associated with its disposal; and be it

RESOLVED, further, that the discharger may be required to submit technical reports relative to the waste discharge as provided under Section 13055 of Division 7, California Water Code.

If, in the future, there is a change in the conditions of the discharge, or use of the disposal area, it may be necessary for the Central Valley Regional Water Quality Control Board to revise these requirements.

These requirements do not constitute a license or permit; neither do they authorize the commission of any act resulting in injury to the property of another, nor do they protect the discharger from his liabilities under Federal, State, or local laws.

/s/ John Van Assen
Chairman

ATTEST:

/s/ Charles T. Carnahan
Executive Officer

APPENDIX B

SAMPLING AT SWIFT AND COMPANY PLANT

DATE: ____________________

COLLECTOR: ____________________

Sample Station	Station Location	Time Sample Taken	Temperature F°	Flow Measurement					Flow Rate (MGD)
				Upstream Station	Depth of Flow (in.)	Downstream Station	Depth of Flow (in.)	Time (min)	
S-1	MK-34			MK-34 Outlet		Paunch Pit Inlet			LEAVE BLANK
S-2	MK-32			MK-32 Outlet		Grease Pit Inlet			
AF-1	Alum Feed								
S-3	Paunch Separator Effluent			—	—	—	—	—	
S-4A	Grease Separator Effluent			—	—	—	—	—	
S-4B	Grease Separator Effluent			—	—	—	—	—	
S-5	MK-2 18" Inlet			MK-2 Outlet		MK-7 24" Inlet			
S-6	MK-2 8" Inlet			Clean-out in Boiler Bldg	—	MK-2 8" Inlet			
S-7	MK-6			MK-6		MK-7			
S-8	Parshall Flume			Meter Readings Counter ☐☐☐☐☐☐☐ x100 Gals.		Flowrate ____ mgd			

(7/69)

APPENDIX C

CITY SEWER SERVICE CHARGES BY SWIFT AND COMPANY

Estimated, 1969 (See Table V-4)		$ 21,395
Based on BOD	$ 8,523	
Based on Quantity	9,452	
Customer Service	3,420	

With a treatment plant at Swift, the annual savings to Swift in reduced sewer service charges would be about $8,523, based on 1969 flows and wasteload.

If Swift goes on a 2-shift operation, wastewater discharges average 1.5 MGD, and BOD averages 1200 ppm, the sewer service charges based on the current rate schedule would be as follows:[1]

Monthly Charges	
Volume: 1.5 MGD x 21 days/mo x $22/MG	690
BOD: (1200 - 400) ppm x 31.5 MG x 0.00834 x $5.06	1,060
Customer Service	285
Subtotal	$ 2,035
Yearly Cost	$ 24,420
Annual Demand Charge, based on maximum month	
Volume: 0.90 x 2.0 MGD x 21 days/mo x $110/MG	$ 4,160
BOD: 0.90 x 2.0 MGD x 21 days/mo x 1200 ppm x 0.00834 x $7.20	2,720
Subtotal	$ 6,880
Total Annual Cost	$ 31,300

Based on BOD	$15,440
Based on Quantity	12,440
Customer Service	3,420

With a treatment plant at Swift, the annual savings to Swift in reduced sewer charges would be approximately $15,400.

The City is considering an increase in sewer service charges. No decisions have been made on this matter to date. For this estimate, the following rates were assumed:[1]

Monthly Charges
Volume: $44/MG
BOD: $7/1000 lb BOD
Customer Service: $400/mo

CITY SEWER SERVICE CHARGES BY SWIFT AND COMPANY

Annual Demand Charge
Volume: $200/MG in the maximum month
BOD: $10/MG in the maximum month

Using these assumed rates, charges levied on Swift would be as follows:

Monthly Charges	
Volume: 1.5 MGD x 21 days/mo x $44/MG	$ 1,390
BOD: 1200 ppm x 31.5 MG x 0.00834 x $7	2,210
Customer Service	400
Subtotal	$ 4,000
Yearly Cost	$ 48,000
Annual Demand Charge	
Volume: 2.0 MGD x 21 days/mo x $200/MG	$ 8,400
BOD: 2.0 MGD x 21 days/mo x 1200 ppm x 0.00834 x $10	4,200
Subtotal	$ 12,600
Total Annual Cost	60,600

Based on BOD	30,720
Based on Quantity	25,080
Customer Service	4,800

If a treatment plant at Swift provided 90% BOD reduction, the annual savings to Swift in reduced sewer charges would be about $27,600.

---

[1] Calculations have been rounded off.

APPENDIX D

SAMPLING IN STOCKTON SOUTHERN INDUSTRIAL TRUNK SEWER

DATE: ____________________
COLLECTOR: ____________________

Sample Station	Station Location	Time Sample Taken	Temperature F°	Flow Measurement				
				Upstream Station	Depth of Flow (in.)	Downstream Station	Depth of Flow (in.)	Time (min)
S-9	Sta. $272+82^{98}$ M.H. #29 Sheet No. 11[1]			Sta. $283+41^{14}$ M.H. #30 Sheet No. 12[1]		Sta. $272+82^{98}$ M.H. #29 Sheet No. 11[1]		
LEAVE BLANK								
S-10	Manhole at 8th and Argonaut Streets			Manhole at 8th and Argonaut Streets		First Manhole Downstream		
LEAVE BLANK								

---

[1] Refer to City of Stockton, Southern Industrial Sanitary Trunk, Plan and Profile, Dwg. No. 6107

APPENDIX E

SEWER PROTECTION BY HYDROGEN PEROXIDE

DESIGN CRITERIA

A. **11,916 ft length of 30 in. R.C.P. from Swift plant to Airport Way**

Reasonably small dosages of hydrogen peroxide were found to be ineffective in protecting the sewer without upstream treatment. The wasteload of the sewage reduced the half-life of the peroxide to the point that it was consumed within 15 minutes.

Therefore, this type of in-sewer treatment could only be considered after pretreatment. Sulfide generation within the 11,916 ft length of 30 in. R.C.P. sewer following upstream treatment at Swift should be minimal; therefore no hydrogen peroxide would be applied to the sewer in this length.

B. **17,925 ft length of 42 in. R.C.P. from Airport Way to MH 11 on** Eighth Street near Argonaut Street

Criterion: Apply at two points

1. At Airport Way, regardless of season
   - a. Average Flow rates:
     - Non-canning season: 2.3 mgd (9 months)
     - Canning season: 3.0 mgd (3 months)
   - b. Feed rates:
     - Non-canning season: 2 ppm H_2O_2
     - Canning season: 3 ppm H_2O_2
   - c. Install underground in existing sewer casement
   - d. Proportional feed pump, controlled by level in sewer and time clock
   - e. Quantity:
     - Non-canning season:

$$2.3 \times 8.34 \times 2 = 38 \text{ lb/day}$$

$$35\% \text{ solution: } \frac{38}{8.34 \times 0.35} = 13 \text{ gal/day}$$

     - Canning season:

$$3.0 \times 8.34 \times 3 = 75 \text{ lb/day}$$

$$35\% \text{ solution: } \frac{75}{8.34 \times 0.35} \quad 26 \text{ gal/day}$$

   - f. On-site storage: 14 days x 26 = 364 gal
2. 8,000 ft downstream of Airport Way, only during canning season

SEWER PROTECTION BY HYDROGEN PEROXIDE

DESIGN CRITERIA

a. Average flow rate: 4 mgd
b. Feed rate: 3 ppm H_2O_2
c. Install underground in existing sewer easement
d. Proportional feed pump, controlled by level of flow.
e. Quantity: 4 x 8.34 x 3 = 100 lb/day

$$35\%\ \text{solution: } \frac{100}{8.34 \times 0.35} = 34\ \text{gal/day}$$

f. On-site storage: 14 days x 34 = 476 gal

C. 10,509 ft length of 48 in. R.C.P. from MH 11 to Main Water Quality Control Plant

a. Average flow rates:
    Non-canning season: 3.0 mgd (9 months)
    Canning season: 7.0 mgd (3 months)
b. Feed rates:
    Non-canning season: 2 ppm H_2O_2
    Canning season: 3 ppm H_2O_2
c. Install underground in existing street R/W
d. Proportional feed pump, controlled by level in sewer and time clock
e. Quantity:
    Non-canning season:
        3.0 x 8.34 x 2 = 50 lb/day

$$35\%\ \text{solution: } \frac{50}{8.34 \times 0.35} = 17\ \text{gal/day}$$

    Canning season:
        7.0 x 8.34 x 3 = 175 lb/day

$$35\%\ \text{solution: } \frac{175}{8.34 \times 0.35} = 60\ \text{gal/day}$$

f. On-site storage: 500 gal (8 days)

SEWER PROTECTION BY HYDROGEN PEROXIDE

COST ESTIMATE

A. **12,000 ft length of 30 in. R.C.P. from Swift plant to Airport Way**
No hydrogen peroxide addition to this length of sewer.

B. **18,000 ft length of 42 in. R.C.P. from Airport Way to MH 11 on**
Eighth Street near Argonaut Street

1. At Airport Way

Storage tank, plastic, 400 gal, installed underground with piping and hold-down concrete		$ 5,000
Proportional Feeder		
Pumps (2) purchased	$ 800	
Concrete vault	5,000	
Pump installation	500	
Piping	300	
		6,600
Electrical & Instrumentation		
Service connection	2,000	
Liquid level indicator/ controller	1,500	
Wiring	1,500	
Time clocks and relays	200	
Control wiring	300	
		5,500
Site development for year-round access		1,500
Subtotal		18,600
Engineering and Contingencies - 25%		4,700
Total		23,300

2. 8,000 ft downstream of Airport Way

Storage tank, plastic, 500 gal, installed underground with piping and hold-down concrete	6,000
Proportional feeder, same as B.1 above	6,600
Electrical "	5,500
Site development "	1,500
Subtotal	19,600

SEWER PROTECTION BY HYDROGEN PEROXIDE

COST ESTIMATE

Engineering and Contingencies - 25%	$ 4,900
Total	24,500

C. **10,500 ft length of 48 in. R.C.P. from MH 11 on** Eighth Street near Argonaut Street to Main Water Quality Control Plant

Storage tank, same as B.2 above	6,000
Proportional feeder, same as B.1 above	6,600
Electrical "	5,500
Site development	0
Subtotal	18,100
Engineering and Contingencies - 25%	4,500
Total	22,600

Total for 3 Stations	$70,400

SEWER PROTECTION BY HYDROGEN PEROXIDE

ESTIMATED ANNUAL COSTS

Operation and Maintenance	
Labor to Maintain 3 Stations	
1 man, 1 day/wk @ $5/hr x 8 hr/day x 52 wk/yr	$ 2,100
Supplies and Repairs	
15% of equipment cost = 0.15 x $10,000	1,500
Power Costs	
$6/station/mo x 12 mo/yr x 3 stations	200
Chemical Costs	
Station at Airport Way	
Non-canning season - 28 lb/day x 270 days/yr = 7,560 lb/yr	
Canning season - 75 lb/day x 90 days/yr = 6,750 lb/yr	
14,000 lb/yr x $0.25/lb	3,500
Station 8,000 ft downstream of Airport Way	
Canning season only - 100 lb/day x 90 days/yr x $0.25/lb	2,300
Station on Eighth Street near Argonaut Street	
Non-canning season - 50 lb/day x 270 days/yr = 13,500 lb/yr	
Canning season - 175 lb/day x 90 days/yr = 15,750 lb/yr	
29,250 lb/yr x $0.25/lb	7,300
Subtotal	$ 16,900
Supervision, Overhead, Contingencies - 20%	3,400
Total Operation and Maintenance	$ 20,300
Amortized Capital Cost	
7% interest, 20 yr life	
Capital recovery factor 0.09439	
Construction cost - $70,400	
Annual cost based on total construction cost = $70,400 x 0.09439	$ 6,600
Annual cost based on 54% of construction cost (Federal grant pays for 46% of construction cost) = $38,000 x 0.09439	(3,600)[1]
Totals	$ 26,900 (23,900)

---

[1] Amounts in parentheses exclude amortization of Federal grant funds.

APPENDIX F

SEWER PROTECTION BY U-TUBE INSTALLATION

DESIGN CRITERIA

A. At Swift Plant

Case I: with an upstream treatment plant
Locate at plant effluent upstream of Parshall flume
Depth of U-Tube = 40 ft
Flow: 1.5 mgd = 2.32 cfs
Inlet D.O. = 39% of saturation = 3.0 ppm
Outlet D.O. = 100% of saturation = 7.7 ppm
Air to water ratio = 15% by volume
Air flow = 0.35 cfs = 21 cfm @ 1 psi
Use 10 in.pipe for U-Tube
Velocity of water = 4.25 ft/sec
Head loss = 4.4 ft; no pump required because there is excess head from plant effluent to sewer

Case II: without an upstream treatment plant
Locate in the area of the Parshall flume
Depth of U-Tube = 40 ft
Flow: 1.5 mgd = 2.32 cfs
Inlet D.O. = 0
Outlet D.O. = 70% of saturation = 5.4 ppm
Air to water ratio = 15% by volume
Air flow = 0.35 cfs = 21 cfm @ 12 psi
Use 12 in.pipe for U-Tube
Velocity of water = 3.05 ft/sec
Head loss = 0.54 ft - 1.00 ft = -0.46 ft(increase in head)

B. Consumption of O_2 in Sewer

Based on laboratory tests, in an "unstirred" condition which simulated flow in a sewer, oxygen would be consumed at a rate of about 7 ppm/hr.

Case I: with an upstream treatment plant
Velocity in 30 in. trunk sewer, flowing 1/2 full, is about 3 ft/sec
Time for D.O. level to drop from 7.7 ppm at the U-Tube at the Swift plant to 0 would be $\frac{7.7}{7} = 1.1$ hr
Distance downstream = 1.1 x 60 x 60 x 3 = 11,900 ft
Install U-Tube at Airport Way

Case II: without an upstream treatment plant
Time for D.O. level to drop from 5.4 ppm at the Parshall flume to 0 would be $\frac{5.4}{7} = 0.77$ hr

SEWER PROTECTION BY U-TUBE INSTALLATION

DESIGN CRITERIA

Distance downstream = 0.77 x 60 x 60 x 3 = 8,300 ft
Install U-Tube 6,000 ft downstream and another 12,000 ft downstream at Airport Way

D. O. level at Airport Way at outlet of U-Tube = 6.2 ppm
Time for D.O. level to drop to 0.5 ppm = $\frac{5.7}{7}$ = 0.814 hr
Distance downstream, assuming a velocity of 2 ft/sec = 0.014 x 60 x 60 x 2 = 5,860 ft; say 6,000 ft

Install U-Tube 6,000 ft downstream of Airport Way. Install another U-Tube 12,000 ft downstream of Airport Way and another at beginning of 48 in. sewer on Eighth Street near Argonaut Street. No additional U-Tubes justified due to relatively short lengths of sewer from sources of waste water, and excessive fluctuations in flow rates in the 48 in. trunk sewer.

C. At Airport Way

Flow: 3.0 mgd = 4.65 cfs average; 6.0 mgd maximum
Inlet D.O. = 0
Outlet D.O. = 80% of saturation = 6.2 ppm
Air to water ratio = 15% by volume based on average flow
Air flow = 0.70 cfs = 42 cfm normal; maximum = 85 cfm @ 12 psi
With 25 ft submergence of air diffusor, 12 in of head is gained by air addition
Use 16 in. pipe for U-Tube
Velocity of water @ 3.0 mgd = 3.4 ft/sec; @ 6.0 mgd = 6.8 ft/sec
Head loss @ 3.0 mgd = 0.67 ft - 1.00 ft = -0.33 ft (increase in head)
Head loss @ 6.0 mgd = 2.7 - 1.0 = 1.7 ft; there will be some overflow

D. 6,000 ft and 12,000 ft Downstream of Airport Way

Flow: 4.0 mgd = 6.2 cfs average; 8.0 mgd maximum
Inlet D.O. = 0.5
Outlet D.O. = 80% of saturation = 6.2 ppm
Air to water ratio = 15% by volume based on average flow
Air flow = 0.93 cfs = 56 cfm normal; maximum = 112 cfm @ 12 psi
With 25 ft submergence of air diffusor, 12 in of head is gained by air addition
Use 20 in. pipe for U-Tube
Velocity of water @ 4.0 mgd = 2.8 ft/sec; @ 8.0 mgd = 5.6 ft/sec

SEWER PROTECTION BY U-TUBE INSTALLATION

DESIGN CRITERIA

Head loss @ 4.0 mgd = +0.43 - 1.00 = -0.57 ft(increase in head)
Head loss @ 8.0 mgd = 1.7 - 1.0 = 0.7 ft ; there will be some overflow

E. On Eighth Street Near Argonaut Street

Flow: 7.0 mgd = 10.8 cfs average; 11.0 mgd maximum
Inlet D.O. = 0.5
Outlet D.O. = 6.2 ppm
Air to water ratio
Air flow = 1.6 cfs = 96 cfm, average; 2.5 cfs - 150 cfm, maximum
With 25 ft submergence of air diffuser, 12 in of head is gained by air addition
Use 24 in.pipe for U-Tube
Velocity of water @ 7.0 mgd = 3.44 ft/sec; @ 11.0 mgd = 5.4 ft/sec
Head loss @ 7.0 mgd = 0.55 - 1.0 = -0.45 ft (increase in head)
Head loss @ 11.0 mgd = 1.3 - 1.0 = 0.30 ft there will be some overflow

SEWER PROTECTION BY U-TUBE INSTALLATION

COST ESTIMATE

A. At Swift Plant Following Upstream Treatment

Blower, 21 cfm @ 1 psi - 1 HP		
Equipment purchase	$ 1,000	
Equipment installation	1,000	
Housing - within treatment plant control building	______	
		$ 2,000
Electrical		
Service	1,000	
Distribution panel, wiring, starter	1,000	
		2,000
Plumbing		
Air piping and valve	500	
10 in.U-Tube		
C.I.P. purchase, 100 ft @ $5	500	
Installation 100 ft @ $30	3,000	
Sewer connection	1,000	
		5,000
Site Development		0
Subtotal		9,000
Engineering and Contingencies - 25%		2,300
Total		$11,300

B. At Swift Plant and 6,000 ft Downstream, with no Upstream Treatment

Blower, 21 cfm @ 12 psi - 10 HP		
Equipment purchase	2,500	
Equipment installation	1,500	
Housing - insulated steel building	1,200	
		5,200
Electrical		
Service	1,000	
Distribution panel, wiring, starter	2,000	
		3,000
Plumbing		
Air piping and valve	700	

SEWER PROTECTION BY U-TUBE INSTALLATION

COST ESTIMATE

12 in. U-Tube		
C.I.P. purchase 100 ft @ $8	$ 800	
Installation 100 ft @ $40	4,000	
Sewer connection	1,500	
		$ 7,000
Site Development		2,000
Subtotal		17,200
Engineering and Contingencies - 25%		4,300
Total, each		21,500
Total for two		43,000

C. At Airport Way

Blower, 85 cfm @ 12 psi - 15 HP		
Equipment purchase	3,500	
Equipment installation	2,000	
Housing - insulated steel building	1,200	
		6,700
Electrical		
Service	1,000	
Distribution panel, wiring, starter	2,000	
		3,000
Plumbing		
Air piping and valve	700	
16 in. U-Tube		
C.I.P. purchase 100 ft @ $12	1,200	
Installation 100 ft @ $45	4,500	
Sewer connection	2,000	
		8,400
Site Development		2,000
Subtotal		20,100
Engineering and Contingencies - 25%		5,000
Total		25,100

SEWER PROTECTION BY U-TUBE INSTALLATION

COST ESTIMATE

D. 6,000 ft and 12,000 ft Downstream of Airport Way

Blower, 112 cfm @ 12 psi - 20 HP		
Equipment purchase	$ 4,000	
Equipment installation	2,000	
Housing - insulated steel building	1,200	
		$ 7,200
Electrical		
Service	1,200	
Distribution panel, wiring, starter	2,000	3,200
Plumbing		
Air piping and valve	800	
20 in.U-Tube		
C.I.P. purchase 100 ft @ $16/ft	1,600	
Installation 100 ft @ $55/ft	5,500	
Sewer connection	2,500	
		10,400
Site Development		2,000
Subtotal		22,800
Engineering and Contingencies - 25%		5,700
Total, each		28,500
Total for two		57,000

E. On Eighth Street, Near Argonaut Street

Blower, 150 cfm @ 12 psi - 20 HP		
Equipment purchase	4,500	
Equipment installation	2,500	
Housing - insulated steel building	1,500	
		8,500
Electrical		
Service	1,500	
Distribution panel, wiring, starter	2,500	
		4,000
Plumbing		
Air piping and valve	1,000	
24 in.U-Tube		
C.I.P. purchase 100 ft @ $20/ft	2,000	
Installation 100 ft @ $70/ft	7,000	
Sewer connection	3,000	
		13,000
Site Development		2,000

SEWER PROTECTION BY U-TUBE INSTALLATION

COST ESTIMATE

Subtotal	$ 27,500
Engineering and Contingencies - 25%	6,900
Total	34,400
Total for 5 U-Tubes, with upstream treatment	127,800
Total for 6 U-Tubes, without upstream treatment	159,500

5 U-TUBE STATIONS, WITH UPSTREAM TREATMENT

ESTIMATED ANNUAL COSTS

Operation and Maintenance	
Labor	
1 man, 1-1/2 days/wk @ \$5/hr x 8 hr/day x 52 wk/yr	\$ 3,100
Supplies and Repairs	
10% of equipment cost = 0.10 x \$18,000	1,800
Power Costs	
Drives - 1-1 HP, 1-15 HP, 3-20 HP, = total of 76 HP	
Operate continuous at 2/3 load	
40 KW x 24 hr/day x 260 days/yr x 1.5¢/kw-hr	3,700
Subtotal	8,600
Supervision, Overhead, Contingencies - 20%	1,700
Total Operation and Maintenance	10,300
Amortized Capital Cost	
\$128,400 construction cost	
7% interest, 20 yr life	
Capital recovery factor = 0.09439	
Annual cost, based on total construction cost = \$127,800 x 0.09439	\$ 12,100
Annual cost, based on 54% of construction cost (Federal grant pays for 46% of construction cost) \$69,000 x 0.09439	6,500
Totals	22,400 (16,800)[1]

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[1] Amounts in parentheses exclude amortization of Federal grant funds.

6 U-TUBE STATIONS WITHOUT UPSTREAM TREATMENT

ESTIMATED ANNUAL COSTS

Operation and Maintenance	
Labor	
1 man, 2 days/wk @ $5/hr x 8 hr/day x 52 wk/yr	$ 4,200
Supplies and Repairs	
10% of equipment cost = 0.10 x $22,000	2,200
Power Costs	
Drives - 2-10 HP, 1-15 HP, 3-20 HP, = total of 95 HP	
Operate continuous at 2/3 load	
50 KW x 24 hr/day x 365 days/yr x 1.5¢/kw-hr	6,600
Subtotal	13,000
Supervision, Overhead, Contingencies - 20%	2,600
Total Operation and Maintenance	15,600
Amortized Capital Cost	
$157,700 construction cost	
7% interest, 20 yr life	
Capital recovery factor = 0.09439	
Annual cost, based on total construction cost = $157,700 x 0.09439	$ 14,900
Annual cost, based on 54% of construction cost (Federal grant pays for 46% of construction cost) = $85,200 x 0.0939	(8,000)[1]
Totals	30,500 (23,600)

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[1] Amounts in parentheses exclude amortization of Federal grant funds.

APPENDIX G

SEWER PROTECTION BY HYDRAULIC FLUSHING

COST ESTIMATE

A. 11,916 ft length of 30 in. R.C.P. from Swift plant to Airport Way - five 30 in. Fabridams required

Equipment cost, complete including compressor, piping, controls, dam fabric, sewer pipe attachments, electrical	$ 3,200
Equipment installation in exist. manhole and above-ground housing	900
Above-ground housing (slab and 6 ft x 6 ft x 7 ft enclosure)	1,000
Electrical service connection	1,000
Underground piping from housing to manhole	500
Subtotal	6,600
Engineering and Contingencies - 25%	1,700
Total, each	8,300
Total for five	41,500

B. 17,925 ft length of 42 in. R.C.P. from Airport Way to MH 11 on Eighth Street near Argonaut Street - three 42 in. Fabridams required

Equipment cost, complete including compressor, piping, controls, dam fabric, sewer pipe attachments, electrical	$ 3,900
Equipment installation in exist. manhole and above-ground housing	1,000
Above-ground housing (slab and 6 ft x 6 ft x 7 ft enclosure)	1,000
Electrical service connection	1,000
Underground piping from housing to manhole	500
Subtotal	7,400
Engineering and Contingencies - 25%	1,900
Total, each	9,300
Total for three	27,900

C. 10,509 ft length of 48 in. R.C.P. from MH 11 on Eighth Street near Argonaut Street to Main Water Quality Control Plant - two 48 in. Fabridams required.

SEWER PROTECTION BY HYDRAULIC FLUSHING

COST ESTIMATE

Equipment cost, complete including compressor, piping, controls, dam fabric, sewer pipe attachments, electrical	$ 4,300
Equipment installation in existing manhole and above-ground housing	1,100
Above-ground housing (slab and 6 ft x 6 ft x 7 ft enclosure)	1,000
Electrical service connection	1,000
Underground piping from housing to manhole	500
Subtotal	7,900
Engineering and Contingencies - 25%	2,000
Total, each	9,900
Total for two	18,800
Total for 10 Stations	88,200

SEWER PROTECTION BY HYDRAULIC FLUSHING

ESTIMATED ANNUAL COSTS

Operation and Maintenance	
Labor to Maintain 10 Stations	
1 man, 1 day/wk @ $5/hr x 8 hr/day x 52 wk/yr	$ 2,100
Supplies and Repairs	
10% of equipment cost = 0.10 x $36,300	3,600
Power Costs	
$6/station/mo x 12 mo/yr x 10 stations	700
Subtotal	6,400
Supervision, Overhead, Contingencies - 20%	1,300
Total Operation and Maintenance	7,700
Amortized Capital Cost	
7% interest, 20 yr life	
Capital recovery factor = 0.09439	
Construction cost - $88,200	
Annual cost based on total construction cost = $88,200 x 0.09439	8,300
Annual cost based on 54% of construction cost (Federal grant pays for 46% of construction cost) = $47,600 x 0.09439	(4,500)[1]
Totals	16,000 (12,200)

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[1] Amounts in parentheses exclude amortization of Federal grant funds.

APPENDIX H

UPSTREAM TREATMENT PLANT WITH COMPRESSED AIR DIFFUSION SYSTEM

DESIGN CRITERIA

Flow: 1.5 mgd Ultimate Average Weekday
1040 gpm Average
Maximum Rate: 2080 gpm = 4.7 cfs

Strength: 1200 ppm BOD
15,200 lb/day
632 lb/hr

Aeration:
Detention: 6 hrs
Required Volume: 50,000 cu ft
Average Loading: 300 lb/1000 cu ft
Cover Aeration Basin

Case I:
Air Transfer Rate = 6% under standard conditions

$= \frac{6}{1.4} = 4.3\%$ for actual conditions using conventional air diffusers

BOD Removal: 90% - 0.90 x 15,200 = 13,700 lb/day

Required O_2 Input: $\frac{13,700}{.043} = 318,000$ lb/day

Required Air Input: $\frac{318,000 \text{ lb/day}}{.086 \text{ lb/cu ft} \times 0.21} = 17,900,000$ cu ft/day

= 12,400 cfm @ 7.5 psi

Case II:
Air Transfer Rate = 8.6% for actual conditions using fine bubble diffusers

Required O_2 Input: $\frac{13,700}{.086} = 159,000$ lb/day

Required Air Input: 9,000,000 cu ft/day = 6,300 cfm @ 7.5 psi

Aeration Basin Geometry:
Volume: 50,000 cu ft
Depth: 15 ft
Surface Area: 3,333 sq ft
Use 2 tanks, each 1,670 sq ft
Inner Shell for Settling has 37 ft Diameter: 1,075 sq ft
Area of Inner plus Outer Shells: 2,845 sq ft
Outer Shell Diameter: 60 ft

UPSTREAM TREATMENT PLANT WITH COMPRESSED AIR DIFFUSION SYSTEM

DESIGN CRITERIA

Settling:

Surface Rise Rate: 700 gal/sq ft
Minimum Surface Area: 2,150 sq ft
Depth: 15 ft
Volume: 32,000 cu ft
Detention: 3.8 hrs
Use 2 clarifiers, each with 1,075 sq ft surface area (37 ft diameter)

Pumps:

Raw Sewage
Average Flow: 1040 gpm
Maximum Flow: 2080 gpm ; use 3 - 1100 gpm pumps @ 30 ft TDH

Return Sludge: 100% maximum = 1040 gpm
Air flow up to 1000 cfm @ 7.5 psi

UPSTREAM TREATMENT PLANT WITH COMPRESSED AIR DIFFUSION SYSTEM

COST ESTIMATE

Bar Screen (Manual) for Raw Sewage, Installed in Wet Pit		$ 2,000
Raw Sewage Pumps		
3 - 1,100 gpm @ 30 ft THD, 20 HP Vertical pedestal mount	$ 11,200	
Concrete Wet Pit	5,000	
Dry Pit	5,000	
Installation	5,000	26,200
Aeration and Settling Tanks		
Equipment Purchase, including freight:		
2 tanks, 60 ft diameter outer shell plus inner shell; sludge collector; air lift return sludge; 3 - 200 HP blowers; 4000 cfm @ 7.5 psi (one blower standby, 2 normally operating); weirs; catwalks; fine bubble diffusers	230,000	
Tax	10,500	
Equipment Installation		
Steel tanks, 2 @ $7,000	14,000	
Inner steel walls	7,000	
Mechanical equipment	40,000	
Air piping, 200 ft @ $20	4,000	
Concrete slabs, 2 x $(60\ \text{ft})^2$ x 0.786 x 1 ft x 1/27 cu yd/cu ft @ $60/cu yd	12,600	
Steel tank covers, 2 @ $10,000 (furnish and install)	20,000	338,100
Plumbing		
Influent Piping and Valves	5,000	
Bypass Piping and Valve	3,000	
Tank Interconnection Piping and Valves	2,500	
Tank Effluent Piping, 200 ft - 18 in. @ $18/ft	3,600	
130 ft - 24 in. @ $24/ft	3,100	
Effluent Valves	1,200	
Miscellaneous Piping and Valves	4,000	
Water Service	1,000	
Water Piping in Control Building and Around Tanks, 500 ft @ $3/ft	1,500	24,900
Electrical		
300 KW Demand Service	7,000	

UPSTREAM TREATMENT PLANT WITH COMPRESSED AIR DIFFUSION SYSTEM

COST ESTIMATE

Distribution Panel, 700 HP load, motor starters, distribution wiring	$ 18,000	
Instrumentation and Controls	15,000	$ 40,000
Control Building and Engine Room		
80 ft x 40 ft x $15/sq ft	48,000	
Minimum Laboratory Test Apparatus	4,000	52,000
Site Development		
Fine Grading	1,000	
Access Road	1,000	
Drainage Culvert	1,000	
Gravel - 250 ft x 150 ft x $0.10/sq ft	3,800	
Paving - 10,000 sq ft x $0.20/sq ft	2,000	
Yard Lighting	1,000	
Landscaping	4,000	13,800
Subtotal		$497,000
Engineering and Contingencies - 25%		124,300
Total		$621,300

UPSTREAM TREATMENT PLANT WITH COMPRESSED AIR DIFFUSION SYSTEM

ESTIMATED ANNUAL COSTS

Operation and Maintenance	
Personnel	
2 full-time operators and 1 half-time operator @ $10,000/yr	$ 25,000
Telephone @ $8/mo x 12 mo/yr	100
Supplies and Repairs	
10% of equipment costs = 0.10 x $206,200	20,600
Power Costs	
500 HP connected load (plus standby) operate at 2/3 load, 16 hr/day, 5-days/wk; 200 HP operate at 2/3 load, 8 hr/day, 5-days/wk; 100 HP operate at 2/3 load, 8 hr/day, 2-days/wk	
Consumption: 250 KW x 16 hr/day x 5-days/wk = 20,000 kw-hr/wk 100 KW x 8 hr/day x 5-days/wk = 4,000 kw-hr/wk 50 KW x 24 hr/day x 2-days/wk = 2,400 kw-hr/wk	
Total weekly consumption = 26,400 kw-hr/wk	
Cost = 1.2¢/kw-hr x 26,400 kw-hr/wk x 52 wk/yr	16,500
Subtotal	$ 62,200
Supervision, Overhead, Contingencies - 20%	12,400
Total Operation and Maintenance	$ 74,600
Amortized Capital Costs	
7% Interest, 20 Yr Life	
Capital Recovery Factor = 0.09439	
$621,300 Construction Cost	
Annual Cost Based on Total Construction Cost = $621,300 x 0.09439	58,600
Annual Cost Based on 54% of Construction Cost = $335,500 x 0.09439	(31,700)[1]
Totals	$133,200 (106,300)

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[1] Amounts in parentheses exclude amortization of Federal grant funds.

APPENDIX I

UPSTREAM TREATMENT PLANT WITH MECHANICAL FLOATING AERATORS

DESIGN CRITERIA

Flow: 1.5 mgd Ultimate Average Weekday
1040 gpm Average
Maximum Rate: 2 x 1040 = 2,080 gpm = 4.7 cfs

Strength: 1200 ppm BOD
15,200 lb/day
632 lb/hr

Aeration:
Detention: 6 hrs
Required Volume: 50,000 cu ft
Aeration Loading: 300 lb/1000 cu ft

HP Required: $\frac{632 \text{ lb/hr}}{2 \text{ lb/HP/hr}} = 316 \text{ HP}$

Use 2 - 60 HP and 4 - 50 HP units
Spray impingement diameter = 35 ft
Physical diameter of unit = 11 ft
Cover Aeration Basin

Reaeration:
Detention: 1 hr
Required Liquid Volume: 8,300 cu ft
O_2 Input: 1.5 lb/lb BOD = 23,000 lb/day
Air Input: = 190 cfm @ 7.5 psi
Use 2 - 190 cfm blowers for standby and as a factor of safety

Aeration Basin Geometry:
Minimum Width: 40 ft/Aerator
Minimum Spacing of Aerators: 40 ft
Water Depth: 10 ft maximum with 1½:1 side slopes
Overall Basin Dimensions: 90 ft x 130 ft
Water Surface: $80 \text{ ft} \times 80 \text{ ft} + 2 \times 40 \text{ ft} \times 20 \text{ ft} + \pi 20 \text{ ft}^2$
$= 9250 \text{ sq ft}$

Volume: $90 \text{ ft} \left(\frac{50 \text{ ft} + 80 \text{ ft}}{2}\right) 10 \text{ ft} + 120 \text{ ft} \left(\frac{15 \text{ ft}}{2}\right) 10 \text{ ft}$

$= 67,500 \text{ cu ft}$

Actual Detention Time: $\frac{1.5 \times 24}{7.48 \times .0675} = 7.1 \text{ hrs}$

Actual Aeration Loading: 250 lb/1000 cu ft

UPSTREAM TREATMENT PLANT WITH MECHANICAL FLOATING AERATORS

DESIGN CRITERIA

Reaeration Basin Geometry:
Volume: 8,300 cu ft
Depth: 15 ft
Surface Area: 550 sq ft
Use 1 steel tank, 27 ft diameter, without cover

Settling:
Surface Rise Rate: 600 gal/sq ft
Minimum Surface Area: 2,500 sq ft
Detention: 3 hrs
Volume: 25,000 cu ft
Water Depth: 9 ft
Use 60 ft diameter steel tank

Pumps: Raw Sewage and Return Sludge
Average Flow: 1040 gpm
Maximum Flow: 2080 gpm
Maximum Return Sludge: 100% = 1040 gpm
Use 3120 gpm, 12 ft TDH, spiralift pumps

UPSTREAM TREATMENT PLANT WITH MECHANICAL FLOATING AERATORS

COST ESTIMATE

Bar Screen (Manual) for Raw Sewage, Installed in Concrete Basin		$ 4,000
Raw Sewage and Return Sludge Pumps		
2 - 3,120 gpm, 12 ft TDH, 20 HP	$ 15,000	
Pit and Retaining Walls	5,000	
Installation	5,000	25,000
Earthen Aeration Basin, 90 ft x 130 ft x 10 ft W.D.		
Excavation Volume; 67,000 cu ft + 3 ft x 85 ft x 125 ft = 99,000 cu ft = 3,700 cu yd		
Cost of Excavation @ $2/cu yd, including filling excavated dirt on-site	7,400	
Asphalt Lining @ $0.65/sq ft (90 ft + 10 ft)(130 ft + 10 ft) = 14,000 sq ft	9,100	
Floating Aerators		
4 - 50 HP units @ $12,000	48,000	
2 - 60 HP units @ $13,500	27,000	
Shipping - 6 @ $360	2,200	
Tax - 5%	3,800	
Installation - 10%	7,500	
Baffle, 100 ft long x 12 ft high, 1 layer thickness, @ $1.20/sq ft	1,600	
Telescoping Value	1,000	
Automatic Weirs with DO Probes and Controller	13,000	
Flexible Cover, 14,000 sq ft @ $1.50	21,000	141,600
Reaeration Basin with Blower		
Steel Tank, 27 ft diameter	7,500	
2 Reinforcing Rings @ $9/ft	1,600	
Tank Coating (Bitumastic Epoxy System)	1,300	
Excavation	1,200	
Concrete Slab, 30 cu yd @ $60/cu yd	1,800	
Backfill	600	
2 Blowers, 190 cfm @ 1 psi, 2 HP	1,200	
2 Blowers, 190 cfm @ 7.5 psi, 10 HP	3,400	
Blower Housing, Steel Building, 10 ft x 10 ft	1,500	
Air Control System	3,800	
Air Diffusers, Weirs, Catwalks, Installed	12,000	33,900
Clarifier, 60 ft diameter, 9 ft S.W.D., underground		
Excavation, $(65\text{ ft})^2$ x 10 ft x 0.786 x 1/27 cu yd/cu ft @ $2.50/cu yd	3,100	

UPSTREAM TREATMENT PLANT WITH MECHANICAL FLOATING AERATORS

COST ESTIMATE

Equipment Purchase	$ 16,000	
Equipment Installation	3,000	
Concrete Slab, 125 cu yd @ $60/cu yd	7,500	
Steel Tank, without Cover, installed	14,000	
2 Reinforcing Rings @ $9/ft	3,700	
Tank Coating (Bitumastic Epoxy System) @ $0.60/sq ft	2,700	
Backfill	1,500	51,500
Plumbing		
Influent Piping and Valve	2,000	
Bypass Piping and Valve	2,000	
Basin Effluent		
To clarifier, 100 ft @ $20/ft	2,000	
Overflow to sewer with valve	1,000	
Clarifier Influent, Effluent and Return Sludge with Valves	4,000	
Reaeration Basin Influent and Effluent with Valves	3,000	
Air Piping and Valves for Reaeration Basin	4,500	
Miscellaneous Piping and Valves	5,000	
Water Service	1,000	
Water Piping in Control Building and Around Clarifier and Aeration Basins, 600 ft @ $2.50/ft	1,500	26,000
Electrical		
300 KW Demand Service	5,000	
Distribution Panel - 500 HP load, motor starters, distribution wiring	18,000	
Instrumentation and Controls (minimum)	10,000	33,000
Control Building		
30 ft x 40 ft @ $15/sq ft	18,000	
Minimum Laboratory Test Apparatus	4,000	22,000
Site Development		
Fine Grading	1,000	
Access Road	1,000	
Drainage Culvert	1,000	
Gravel (350 ft x 140 ft - 130 ft x 90 ft) @ $0.10/sq ft	3,700	
Paving, 10,000 sq ft @ $0.20/sq ft	2,000	
Yard Lighting	1,000	
Landscaping	4,000	13,700

UPSTREAM TREATMENT PLANT WITH MECHANICAL FLOATING AERATORS

COST ESTIMATE

Subtotal	$350,700
Engineering and Contingencies - 25%	87,700
Total	$438,400

UPSTREAM TREATMENT PLANT WITH MECHANICAL FLOATING AERATORS

ESTIMATED ANNUAL COSTS

Operation and Maintenance	
Personnel	
3 full-time operators @ $10,000/yr	$ 30,000
Telephone @ $8/mo x 12 mo/yr	100
Supplies and Repairs	
10% of equipment costs = 0.10 x $170,000	17,000
Power Costs	
350 HP connected load (plus standby) operate at 2/3 load, 16 hr/day, 5-days/wk;	
200 HP operate at 2/3 load, 8 hr/day, 5-days/wk;	
100 HP operate at 2/3 load, 8 hr/day, 2-days/wk	
Consumption: 175 KW x 16 hr/day x 5-days/wk = 14,000 kw-hr/wk	
100 KW x 8 hr/day x 5-days/wk = 4,000 kw-hr/wk	
50 KW x 24 hr/day x 2-days/wk = 2,400 kw-hr/wk	
Total weekly consumption = 20,400 kw-hr/	
Cost = 1.2¢/kw-hr x 20,400 kw-hr/wk x 52 wk/yr	12,700
Subtotal	$ 59,800
Supervision, Overhead, Contingencies - 20%	12,000
Total Operation and Maintenance	$ 71,800
Amortized Capital Costs	
7% Interest, 20 Yr Life	
Capital Recovery Factor = 0.09439	
$438,400 Construction Cost	
Annual Cost Based on Total Construction Cost = $438,400 x 0.09439	41,400
Annual Cost Based on 54% of Construction Cost (Federal grant pays for 46% of construction cost) = $236,700 x 0.09439	(22,300)[1]
Totals	$113,200 (94,100)

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[1] Amounts in parentheses exclude amortization of Federal grant funds.

APPENDIX J

UPSTREAM TREATMENT PLANT WITH MECHANICAL BRUSH AERATORS

DESIGN CRITERIA

Flow: 1.5 mgd Ultimate Average Weekday
1040 gpm Average
Maximum Rate: 2080 gpm = 4.7 cfs

Strength: 1200 ppm BOD
15,200 lb/day
632 lb/hr

Aeration:
Detention: 24 hr
Aeration Loading: 100 lb BOD/1000 cu ft
Required Volume: 152,000 cu ft
Oxygenation: 1.5 lb OC/lb BOD
OC Required: 1.5 x 632 lb/hr = 950 lb/hr
200 ft Rotor: 4.5 lb/hr/ft rotor

Rotor Submergence: 9 in.
5 Rotors, each 40 ft long with 60 HP drives
Cover Aeration Basin

Reaeration:
Detention: 1 hr
Required Liquid Volume: 8,300 cu ft
O_2 Input: 1.5 lb/lb BOD = 23,000 lb/day
Air Input: = 190 cfm @ 7.5 psi
Use 2 - 190 cfm blowers for standby and as a factor of safety

Aeration Basin Geometry:
Required Volume: 152,000 cu ft
Depth: 13 ft maximum with 1½:1 side slopes
Average Length: 280 ft; total length = 310 ft
Water Area: $62 \text{ ft } (250 \text{ ft} + 3.14 \times \frac{31 \text{ ft}}{2}) = 62(250 + 49)$
$= 18{,}500$ sq ft

Reaeration Basin Geometry:
Volume: 8,300 cu ft
Depth: 15 ft
Surface Area: 550 sq ft
Use 1 steel tank, 27 ft diameter, without cover

Settling:
Surface Rise Rate: 600 gal/sq ft
Required Surface Area: 2,500 sq ft

UPSTREAM TREATMENT PLANT WITH MECHANICAL BRUSH AERATORS

DESIGN CRITERIA

Use 1 tank 60 ft diameter x 9 ft water depth
Volume: 25,000 cu ft
Detention: 3 hrs

Pumps: Raw Sewage and Return Sludge
Average Flow: 1040 gpm
Maximum Flow: 2080 gpm
Maximum Return Sludge: 100% = 1040 gpm
Use 3120 gpm, 12 ft TDH, spiralift pumps

UPSTREAM TREATMENT PLANT WITH MECHANICAL BRUSH AERATORS

COST ESTIMATE

Bar Screen (Manual) for Raw Sewage, Installed in Concrete Basin		$ 4,000
Raw Sewage and Return Sludge Pumps		
2 - 3, 120 gpm, 12 ft TDH, 20 HP	$ 15,000	
Pit and Retaining Walls	5,000	
Installation	5,000	25,000
Earthen Aeration Basin, 320 ft x 72 ft x 13 ft W.D.		
Volume: 152,000 cu ft + 3 ft x 72 ft x 320 ft = 221,000 cu ft = 8,100 cu yd		
Cost of Excavation @ $1.50/cu yd, including filling excavated dirt on-site	12,200	
Asphalt Lining @ $0.06/sq ft (320 ft + 10 ft)(72 ft + 10 ft) = 27,100 sq ft	16,300	
Mammoth Rotors (Brush Aerators)		
Equipment purchase	72,000	
Mounting pedestals (24 @ $300 ea.)	7,200	
Installation	7,200	
Shipping and tax - 8%	5,800	
Baffle, 300 ft long x 15 ft high x 3 ft wide, wood construction, $2/sq ft	9,000	
Telescoping Valve	1,000	
Automatic Weirs with DO Probes and Controller	13,000	
Flexible Cover, 27,100 sq ft @ $1.50/sq ft	40,600	184,300
Reaeration Basin with Blower		
Steel Tank, 27 ft diameter	7,500	
2 Reinforcing Rings @ $9/ft	1,600	
Tank Coating (Bitumastic Epoxy System)	1,300	
Excavation	1,200	
Concrete Slab, 30 cu yd @ $60/cu yd	1,800	
Backfill	600	
2 Blowers, 190 cfm @ 1 psi, 2 HP	1,200	
2 Blowers, 190 cfm @ 7.5 psi, 10 HP	3,400	
Blower Housing, Steel Building, 10 ft x 10 ft	1,500	
Air Control System	3,800	
Air Diffusers, Weirs, Catwalks, installed	12,000	35,900
Clarifier, 60 ft diameter, 9 ft S.W.D., underground		
Excavation, $(65\ \text{ft})^2$ x 10 ft x 0.786 x 1/27 cu yd/cu ft x $2.50/cu yd	3,100	

UPSTREAM TREATMENT PLANT WITH MECHANICAL BRUSH AERATORS

COST ESTIMATE

Equipment Purchase	$ 16,000	
Equipment Installation	3,000	
Concrete Slab, $(65\ \text{ft})^2$ x 0.786 x 1 ft thick x 1/27 cu yd/cu ft x $60/cu yd	7,400	
Steel Tank, without cover, installed	14,000	
2 Reinforcing Rings @ $9/ft	3,700	
Tank Coating @ $0.60/sq ft	2,700	
Backfill	1,500	$ 51,400
Plumbing		
Influent Piping and Valve	2,000	
Bypass Piping and Valve	2,000	
Basin Effluent		
To clarifier, 100 ft @ $20/ft	2,000	
Overflow to sewer with valve	1,000	
Miscellaneous Piping and Valves	5,000	
Clarifier Influent, Effluent and Return Sludge Piping with Valves	3,000	
Reaeration Basin Influent and Effluent with Valves	3,000	
Air Piping and Valves for Reaeration Basin	4,500	
Water Service	1,000	
Water Piping in Control Building and Around Clarifier and Aeration Basins, 1000 ft @ $2.50/ft	2,500	26,000
Electrical		
300 KW Demand Service	5,000	
Distribution Panel - 500 HP load, motor starters, distribution wiring	20,000	
Instrumentation and Controls (minimum)	10,000	35,000
Control Building		
30 ft x 40 ft @ $15/sq ft	18,000	
Minimum Laboratory Test Apparatus	4,000	22,000
Site Development		
Fine Grading of Site	1,000	
Access Road	1,000	
Drainage Culvert	1,000	
Gravel (600 ft x 120 ft - 72 ft x 320 ft) @ $0.10/sq ft	4,900	
Paving, 10,000 sq ft @ $0.20/sq ft	2,000	
Yard Lighting	1,000	
Landscaping	5,000	15,900

UPSTREAM TREATMENT PLANT WITH MECHANICAL BRUSH AERATORS

COST ESTIMATE

Subtotal	**$399,500**
Engineering and Contingencies - 25%	**99,900**
Total	**$499,400**

UPSTREAM TREATMENT PLANT WITH MECHANICAL BRUSH AERATORS

ESTIMATED ANNUAL COSTS

Operation and Maintenance	
Personnel	
3 full-time operators @ \$10,000/yr	\$ 30,000
Telephone @ \$8/mo x 12 mo/yr	100
Supplies and Repairs	
10% of equipment costs = 0.10 x \$180,000	18,000
Power Costs	
350 HP connected load (plus standby) operate at 2/3 lbad, 16 hr/day, 5-days/wk;	
200 HP operate at 2/3 load, 8 hr/day, 5-days/wk;	
100 HP operate at 2/3 load, 8 hr/day, 2-days/wk	
Consumption: 175 KW x 16 hr/day x 5-days/wk = 14,000 kw-hr/wk	
100 KW x 8 hr/day x 5-days/wk = 4,000 kw-hr/wk	
50 KW x 24 hr/day x 2-days/wk = 2,400 kw-hr/wk	
Total weekly consumption = 20,400 kw-hr/wk	
Cost = 1.2¢/kw-hr x 20,400 kw-hr/wk x 52 wk/yr	12,700
Subtotal	\$ 60,800
Supervision, Overhead, Contingencies - 20%	12,200
Total Operation and Maintenance	\$ 73,000
Amortized Capital Costs	
7% Interest, 20 Yr Life	
Capital Recovery Factor = 0.09439	
\$499,400 Construction Cost	
Annual Cost Based on Total Construction Cost = \$499,400 x 0.09439	47,100
Annual Cost Based on 54% of Construction Cost (Federal grant pays for 46% of construction cost) = \$270,000	(25,500)[1]
Totals	\$120,100 (98,500)

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[1] Amounts in parentheses exclude Federal grant funds.